МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ
РОССИЙСКОЙ ФЕДЕРАЦИИ
федеральное государственное бюджетное образовательное учреждение
высшего образования
МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
ГЕОДЕЗИИ И КАРТОГРАФИИ
(МИИГАиК)

Заочный факультет
Кафедра лингвистики

**ДОКУМЕНТ ПОДПИСАН
ЭЛЕКТРОННОЙ ПОДПИСЬЮ**

Сертификат: 5387FD2AF5B17FED816FDE9A1D4973B1
Владелец: Степанченко Алексей Леонидович
Действителен: с 21.07.2025 по 14.10.2026

«УТВЕРЖДАЮ»
Проректор
А. Л. Степанченко
Протокол от 31 мая 2021 г. № 34

ФОНД ОЦЕНОЧНЫХ СРЕДСТВ ПО ДИСЦИПЛИНЕ (МОДУЛЮ) ГУМАНИТАРНЫЕ И СОЦИАЛЬНЫЕ НАУКИ «Б1.О.01.03 ИНОСТРАННЫЙ ЯЗЫК»

Уровень высшего образования: специалитет

Специальность: 21.05.01 Прикладная геодезия

Направленность (профиль) подготовки: Инженерно-геодезическое обеспечение строительства и эксплуатации объектов нефтегазового и энергетического комплексов

Квалификация (степень) выпускника: инженер-геодезист

Форма обучения: заочная

Год набора (приема на обучение): 2021

Срок получения образования: 5 лет 8 месяца(-ев)

Объем: в зачетных единицах: 7 з.е.
в академических часах: 252 ак.ч.

Москва, 2021

Разработчики:
Заведующий кафедрой Лингвистики, доцент Герасимов И. П.

Старший преподаватель кафедры Лингвистики Ацута Е. В.

Старший преподаватель кафедры Лингвистики Трофименко С. А.

Фонд оценочных средств по дисциплине (модулю) составлен в соответствии с требованиями ФГОС ВО по специальности 21.05.01 Прикладная геодезия, утвержденного приказом Минобрнауки от 11.08.2020 № 944

Согласование и утверждение

№	Подразделение	Ответственное лицо	ФИО	Виза	Дата, протокол (при наличии)
1	Заочный факультет	Председатель Учебно-методической комиссии	Литвиненко М. В.	Рассмотрено	15.12.2020, № 5/21

1. Планируемые результаты обучения, соотнесенные с планируемыми результатами освоения образовательной программы

УК-4 Способен применять современные коммуникативные технологии, в том числе на иностранном(ых) языке(ах), для академического и профессионального взаимодействия

УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия

Знать:

УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

Уметь:

УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка

Владеть:

УК-4.1/Нв1 Навыками чтения, аудирования, разговорной речи, письмо в профессиональной области

УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке

Знать:

УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом

Уметь:

УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка

Владеть:

УК-4.2/Нв1 Приемами самостоятельной работы с языковым материалом с использованием справочной и учебной литературы

УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат

Знать:

УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи

Уметь:

УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью

Владеть:

УК-4.3/Нв1 Стратегиями проведения сопоставительного анализа факторов культуры различных стран

УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке

Знать:

УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

Уметь:

УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью

Владеть:

УК-4.4/Нв1 Компенсаторными умениями, помогающими преодолеть "сбои" в коммуникации, вызванные объективными и субъективными, социокультурными причинами

УК-5 Способен анализировать и учитывать разнообразие культур в процессе межкультурного взаимодействия

УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии

Знать:

УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов.

УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций

Уметь:

УК-5.1/Ум1 Определять собственную позицию по отношению к окружающему миру, осознавать самобытность российской истории, и ее непосредственную взаимосвязь с различными этическими, религиозными и ценностными системами, сообществами.

УК-5.1/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций

Владеть:

УК-5.1/Нв1 Приемами исторического описания (рассказ о событиях, процессах, явлениях) и объяснения (раскрытие причин и следствий событий, выявление в них общего и различного, определение их характера, классификация и др.).

УК-5.1/Нв2 Навыками проявления уважительного отношения к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций

УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп

Знать:

УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время;

УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций

Уметь:

УК-5.2/Ум1 Учитывать ценности мировой и российской культуры для развития навыков межкультурного диалога; использовать знание и понимание проблем человека в современном мире;

УК-5.2/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций

Владеть:

УК-5.2/Нв1 Навыками определять и аргументировано представлять собственное отношение к дискуссионным проблемам истории, опираясь на знание мировой и российской истории, социокультурных традиций России и мира.

УК-5.2/Нв2 Навыками проявления уважительного отношения к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций

УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач

Знать:

УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей

УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин

Уметь:

УК-5.3/Ум1 Выстраивать личное и профессиональное общение на основе принципа морального равенства людей как основы социальной интеграции

УК-5.3/Ум2 Принять на себя нравственные обязательства по отношению к природе, обществу, другим людям и к самому себе

Владеть:

УК-5.3/Нв1 Навыками выстраивания общения на основе принципа морального равенства людей как основы социальной интеграции

УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ

Знать:

УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий;

УК-5.4/Зн2 Знает основные категории философии

Уметь:

УК-5.4/Ум1 Ориентироваться в мировом историческом процессе, анализировать процессы и явления, происходящие в обществе; соотносить их с исторически возникшими мировоззренческими системами.

УК-5.4/Ум2 Умеет применять знание основных категорий философии при анализе культурных сообществ

Владеть:

УК-5.4/Нв1 Навыками оценочной деятельности (умение определять и обосновывать свое отношение к историческим и современным событиям, их участникам).

УК-5.4/Нв2 Владеет навыками выявления специфики различных культурных сообществ

2. Показатели и критерии оценивания компетенций

Планируемые результаты освоения программы	Уровень овладения	Критерии оценивания (перечень сформированных ИДК/ЗУВ по уровням освоения)

УК-4 Способен применять современные коммуникативные технологии, в том числе на иностранном(ых) языке(ах), для академического и профессионального взаимодействия	Повышенный	ИДК УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия Знать: УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка Владеть: УК-4.1/Нв1 Навыками чтения, аудирования, разговорной речи, письмо в профессиональной области ИДК УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке Знать: УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом Уметь: УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка Владеть: УК-4.2/Нв1 Приемами самостоятельной работы с языковым материалом с использованием справочной и учебной литературы ИДК УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат Знать: УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи Уметь: УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью

		Владеть: УК-4.3/Нв1 Стратегиями проведения сопоставительного анализа факторов культуры различных стран ИДК УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке Знать: УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью Владеть: УК-4.4/Нв1 Компенсаторными умениями, помогающими преодолеть "сбои" в коммуникации, вызванные объективными и субъективными, социокультурными причинами
	Базовый	ИДК УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия Знать: УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка ИДК УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке Знать: УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом Уметь: УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка

		ИДК УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат Знать: УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи Уметь: УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью ИДК УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке Знать: УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников Уметь: УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью
	Пороговый	ИДК УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия Знать: УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

		ИДК УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке Знать: УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом ИДК УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат Знать: УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи ИДК УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке Знать: УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников

УК-5 Способен анализировать и учитывать разнообразие культур в процессе межкультурного взаимодействия	Повышенный	ИДК УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии Знать: УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов. УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций Уметь: УК-5.1/Ум1 Определять собственную позицию по отношению к окружающему миру, осознавать самобытность российской истории, и ее непосредственную взаимосвязь с различными этическими, религиозными и ценностными системами, сообществами. УК-5.1/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций Владеть: УК-5.1/Нв1 Приемами исторического описания (рассказ о событиях, процессах, явлениях) и объяснения (раскрытие причин и следствий событий, выявление в них общего и различного, определение их характера, классификация и др.). УК-5.1/Нв2 Навыками проявления уважительного отношения к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций ИДК УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп Знать: УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время; УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций

			Уметь: УК-5.2/Ум1 Учитывать ценности мировой и российской культуры для развития навыков межкультурного диалога; использовать знание и понимание проблем человека в современном мире; УК-5.2/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций Владеть: УК-5.2/Нв1 Навыками определять и аргументировано представлять собственное отношение к дискуссионным проблемам истории, опираясь на знание мировой и российской истории, социокультурных традиций России и мира. УК-5.2/Нв2 Навыками проявления уважительного отношения к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций ИДК УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач Знать: УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин Уметь: УК-5.3/Ум1 Выстраивать личное и профессиональное общение на основе принципа морального равенства людей как основы социальной интеграции УК-5.3/Ум2 Принять на себя нравственные обязательства по отношению к природе, обществу, другим людям и к самому себе Владеть: УК-5.3/Нв1 Навыками выстраивания общения на основе принципа морального равенства людей как основы социальной интеграции ИДК УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ Знать: УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий; УК-5.4/Зн2 Знает основные категории философии

		Уметь: УК-5.4/Ум1 Ориентироваться в мировом историческом процессе, анализировать процессы и явления, происходящие в обществе; соотносить их с исторически возникшими мировоззренческими системами. УК-5.4/Ум2 Умеет применять знание основных категорий философии при анализе культурных сообществ Владеть: УК-5.4/Нв1 Навыками оценочной деятельности (умение определять и обосновывать свое отношение к историческим и современным событиям, их участникам). УК-5.4/Нв2 Владеет навыками выявления специфики различных культурных сообществ
	Базовый	ИДК УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии Знать: УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов. УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций Уметь: УК-5.1/Ум1 Определять собственную позицию по отношению к окружающему миру, осознавать самобытность российской истории, и ее непосредственную взаимосвязь с различными этическими, религиозными и ценностными системами, сообществами. УК-5.1/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций ИДК УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп Знать: УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время;

		УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций Уметь: УК-5.2/Ум1 Учитывать ценности мировой и российской культуры для развития навыков межкультурного диалога; использовать знание и понимание проблем человека в современном мире; УК-5.2/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций ИДК УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач Знать: УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин Уметь: УК-5.3/Ум1 Выстраивать личное и профессиональное общение на основе принципа морального равенства людей как основы социальной интеграции УК-5.3/Ум2 Принять на себя нравственные обязательства по отношению к природе, обществу, другим людям и к самому себе ИДК УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ Знать: УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий; УК-5.4/Зн2 Знает основные категории философии Уметь: УК-5.4/Ум1 Ориентироваться в мировом историческом процессе, анализировать процессы и явления, происходящие в обществе; соотносить их с исторически возникшими мировоззренческими системами. УК-5.4/Ум2 Умеет применять знание основных категорий философии при анализе культурных сообществ

	Пороговый	ИДК УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии Знать: УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов. УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций ИДК УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп Знать: УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время; УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций ИДК УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач Знать: УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин ИДК УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ Знать: УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий; УК-5.4/Зн2 Знает основные категории философии

3. Шкала оценивания

Оценка	Критерии оценивания (перечень сформированных ИДК/ЗУВ)
Отлично	УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка УК-4.1/Нв1 Навыками чтения, аудирования, разговорной речи, письмо в профессиональной области УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов. УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций УК-5.1/Ум1 Определять собственную позицию по отношению к окружающему миру, осознавать самобытность российской истории, и ее непосредственную взаимосвязь с различными этическими, религиозными и ценностными системами, сообществами. УК-5.1/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций УК-5.1/Нв1 Приемами исторического описания (рассказ о событиях, процессах, явлениях) и объяснения (раскрытие причин и следствий событий, выявление в них общего и различного, определение их характера, классификация и др.). УК-5.1/Нв2 Навыками проявления уважительного отношения к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка УК-4.2/Нв1 Приемами самостоятельной работы с языковым материалом с использованием справочной и учебной литературы

		УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время; УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций УК-5.2/Ум1 Учитывать ценности мировой и российской культуры для развития навыков межкультурного диалога; использовать знание и понимание проблем человека в современном мире; УК-5.2/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций УК-5.2/Нв1 Навыками определять и аргументировано представлять собственное отношение к дискуссионным проблемам истории, опираясь на знание мировой и российской истории, социокультурных традиций России и мира. УК-5.2/Нв2 Навыками проявления уважительного отношения к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью УК-4.3/Нв1 Стратегиями проведения сопоставительного анализа факторов культуры различных стран УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин УК-5.3/Ум1 Выстраивать личное и профессиональное общение на основе принципа морального равенства людей как основы социальной интеграции УК-5.3/Ум2 Принять на себя нравственные обязательства по отношению к природе, обществу, другим людям и к самому себе УК-5.3/Нв1 Навыками выстраивания общения на основе принципа морального равенства людей как основы социальной интеграции

	УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью УК-4.4/Нв1 Компенсаторными умениями, помогающими преодолеть "сбои" в коммуникации, вызванные объективными и субъективными, социокультурными причинами УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий; УК-5.4/Зн2 Знает основные категории философии УК-5.4/Ум1 Ориентироваться в мировом историческом процессе, анализировать процессы и явления, происходящие в обществе; соотносить их с исторически возникшими мировоззренческими системами. УК-5.4/Ум2 Умеет применять знание основных категорий философии при анализе культурных сообществ УК-5.4/Нв1 Навыками оценочной деятельности (умение определять и обосновывать свое отношение к историческим и современным событиям, их участникам). УК-5.4/Нв2 Владеет навыками выявления специфики различных культурных сообществ
Хорошо	УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-4.1/Ум1 Выполнять переводы технических текстов с иностранного языка УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов. УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций УК-5.1/Ум1 Определять собственную позицию по отношению к окружающему миру, осознавать самобытность российской истории, и ее непосредственную взаимосвязь с различными этическими, религиозными и ценностными системами, сообществами. УК-5.1/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций

		УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом УК-4.2/Ум1 Выполнять перевод технических текстов с иностранного языка УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время; УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций УК-5.2/Ум1 Учитывать ценности мировой и российской культуры для развития навыков межкультурного диалога; использовать знание и понимание проблем человека в современном мире; УК-5.2/Ум2 Проявлять уважительное отношение к историческому наследию и социально-культурным традициям различных народов на основе знания и понимания их философских и этических традиций УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи УК-4.3/Ум1 Осуществляет коммуникацию с зарубежными партнерами; переводит научно-техническую литературу, связанную с профессиональной деятельностью УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин УК-5.3/Ум1 Выстраивать личное и профессиональное общение на основе принципа морального равенства людей как основы социальной интеграции УК-5.3/Ум2 Принять на себя нравственные обязательства по отношению к природе, обществу, другим людям и к самому себе УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-4.4/Ум1 Осуществлять коммуникацию с зарубежными партнерами; переводить научно-техническую литературу по вопросами, связанным с профессиональной деятельностью

	УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий; УК-5.4/Зн2 Знает основные категории философии УК-5.4/Ум1 Ориентироваться в мировом историческом процессе, анализировать процессы и явления, происходящие в обществе; соотносить их с исторически возникшими мировоззренческими системами. УК-5.4/Ум2 Умеет применять знание основных категорий философии при анализе культурных сообществ
Удовлетворительно	УК-4.1 Устанавливает и развивает профессиональные контакты в соответствии с потребностями совместной деятельности, включая обмен информацией и выработку единой стратегии взаимодействия УК-4.1/Зн1 Лексический минимум в объеме 2000 учебных лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-5.1 Анализирует важнейшие идеологические и ценностные системы, сформировавшиеся в ходе исторического развития; обосновывает актуальность их использования при социальном и профессиональном взаимодействии УК-5.1/Зн1 Место и роль России в истории человечества и в современном мире; наиболее существенные связи и признаки исторических явлений и процессов. УК-5.1/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций УК-4.2 Составляет, переводит и редактирует различные академические тексты (рефераты, эссе, обзоры, статьи и т.д.), в том числе на иностранном языке УК-4.2/Зн1 Основные способы работы на языковым и речевым материалом УК-5.2 Выстраивает социальное профессиональное взаимодействие с учетом особенностей основных форм научного и религиозного сознания, деловой и общей культуры представителей других этносов и конфессий, различных социальных групп УК-5.2/Зн1 Основные исторические этапы развития общества; основные тенденции отечественной истории в контексте мировой истории с древнейших времен по настоящее время; УК-5.2/Зн2 Содержание основных философских и этических учений, сформировавшихся в рамках западной, восточной и русской философских традиций УК-4.3 Представляет результаты академической и профессиональной деятельности на различных публичных мероприятиях, включая международные, выбирая наиболее подходящий формат УК-4.3/Зн1 Нормы произношения, лексику иностранного языка общеупотребительного, терминологического и профессионального содержания; типовые способы построения высказываний в устной и письменной речи

	УК-5.3 Обеспечивает создание недискриминационной среды взаимодействия при выполнении профессиональных задач УК-5.3/Зн1 Философскую аргументацию в защиту принципа морального равенства людей УК-5.3/Зн2 Основы исторических, философских, культурологических дисциплин УК-4.4 Аргументированно и конструктивно отстаивает свои позиции и идеи в академических и профессиональных дискуссиях на государственном языке РФ и иностранном языке УК-4.4/Зн1 Лексический минимум в объеме 2000 лексических единиц общего и терминологического характера, необходимого для возможности получения информации профессионального содержания из зарубежных источников УК-5.4 Применяет основные категории исторической науки и философского мировоззрения к анализу специфики различных культурных сообществ УК-5.4/Зн1 Основные даты, участников и результаты важнейших исторических событий; УК-5.4/Зн2 Знает основные категории философии
Неудовле-творительно	Результаты обучения не сформированы на достаточном уровне

4. Контрольные мероприятия по дисциплине

Вид контроля	Форма контроля/Оценочное средство
Текущий контроль	Контрольная работа Практическая работа
Промежуточная аттестация	Контрольная работа Экзамен

№ п/п	Наименование раздела	Контролируемые ИДК	Вид контроля/ используемые оценочные материалы	
			Текущий	Промежут. аттестация
1	Вводно-коррективный курс	УК-4.1 УК-4.2 УК-5.1	Практическая работа	Экзамен
2	Общий курс иностранного языка	УК-4.1 УК-4.2 УК-4.3 УК-5.1 УК-5.2	Практическая работа	Экзамен
3	Профессионально-ориентированный иностранный язык	УК-4.1 УК-4.2 УК-4.3 УК-4.4 УК-5.1 УК-5.2 УК-5.3 УК-5.4	Контрольная работа Практическая работа	Экзамен

5. Порядок проведения промежуточной аттестации

Порядок проведения промежуточной аттестации регламентируется локальными нормативными актами Университета:
- Положением о формах, периодичности, порядке текущего контроля успеваемости и промежуточной аттестации обучающихся по основным образовательным программам высшего образования – программам бакалавриата, программам специалитета, программам магистратуры в федеральном государственном бюджетном образовательном учреждении высшего образования «Московский государственный университет геодезии и картографии», п.6 «Организация и проведение промежуточной аттестации».
- Положением о порядке осуществления образовательного процесса, проведения текущего контроля успеваемости и промежуточной аттестации обучающихся с применением электронного обучения и дистанционных образовательных технологий в федеральном государственном бюджетном образовательном учреждении высшего образования «Московский государственный университет геодезии и картографии», п.8 «Проведение промежуточной аттестации с применением ЭО и ДОТ».

Промежуточная аттестация: Экзамен, 1-я летняя сессия.
При проведении промежуточной аттестации применяется среднее арифметическое значение оценок, полученных за каждый элемент оценивания, указанный в билете (ответ на устный вопрос; просмотр текста и ответ на вопрос по нему; полный письменный перевод текста). Итоговая оценка по дисциплине рассчитывается как отношение суммы оценок к количеству полученных оценок (три). При проведении оценивания по вопросам и заданиям, указанным в билете, в ходе промежуточной аттестации преподаватель может учитывать результаты текущего контроля.

6. Оценочные материалы текущего контроля

Раздел 1. Вводно-коррективный курс
Контролируемые ИДК: УК-4.1 УК-4.2 УК-5.1

Тема 1.1. Моя биография, семья
Форма контроля/оценочное средство: Практическая работа
Вопросы/Задания:
1. Ответьте на вопрос:
What is your name?
2. Ответьте на вопрос:
Have you got a family? Is it big or small?
3. Ответьте на вопрос:
Let’s start with you. Could you tell me a little bit about yourself, where you were born and where you grew up?
4. Ответьте на вопрос:
How many people are there in your family? Could you describe each member and tell me what they do?
5. Ответьте на вопрос:
Do you have any family traditions or hobbies that you all enjoy doing together?
6. Ответьте на вопрос:
How would you describe your relationship with your siblings or other close relatives?

Раздел 2. Общий курс иностранного языка
Контролируемые ИДК: УК-4.1 УК-4.2 УК-4.3 УК-5.1 УК-5.2

Тема 2.1. Современная система образования в России, мой институт
Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

What is the name of your institute (university)?

2. Ответьте на вопрос:

What is your speciality?

3. Ответьте на вопрос:

Could you describe the main stages of higher education in Russia (Bachelor's, Master's, Specialist, Postgraduate)?

4. Ответьте на вопрос:

What are the main differences between the modern Russian education system and the Soviet one?

5. Ответьте на вопрос:

Tell us about your institute (МИГАиК / MIIGAiK or a similar university). Which faculty do you study at, and what is your major?

6. Ответьте на вопрос:

Do you have any practical training (field practice) as part of your course? If so, where do you usually go and what do you do there?

Тема 2.2. Проблемы экологии в современном мире.

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

Is ecology a big problem today?

2. Ответьте на вопрос:

Is ecology a big problem today?

3. Ответьте на вопрос:

What do you consider to be the three most serious environmental problems facing the world today?

4. Ответьте на вопрос:

What is the greenhouse effect, and how does it contribute to global climate change?

5. Ответьте на вопрос:

What are the main sources of air and water pollution in big cities, and how can they be reduced?

6. Ответьте на вопрос:

What can ordinary people do in their daily lives to help protect the environment and reduce their carbon footprint?

Тема 2.3. Страны изучаемого языка

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

What is the official name of Great Britain?

2. Ответьте на вопрос:

What is the weather like in Britain?

3. Ответьте на вопрос:

Briefly describe the geographical position of the UK. What seas and oceans is it washed by?

4. Ответьте на вопрос:

The UK is famous for its variable weather. What is the British climate like?

5. Ответьте на вопрос:

Who is the current Head of State in the UK? What is the role of the Monarch in the British political system?

6. Ответьте на вопрос:

How did the Great Fire of London in 1666 influence the development of the city's architecture and

Тема 2.4. . Система высшего образования в США и Великобритании

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

What are the most famous universities in the USA? (Name one).

2. Ответьте на вопрос:

What are the most famous universities in the UK? (Name one).

3. Ответьте на вопрос:

What are the most prestigious universities in the UK (often called "Oxbridge") and the USA (the "Ivy League")?

4. Ответьте на вопрос:

How does the admission process to a university differ between Russia, the UK, and the USA?

5. Ответьте на вопрос:

What is a Bachelor's degree, and how long does it typically take to earn one in the UK and the USA?

6. Ответьте на вопрос:

What are tuition fees like in the UK and the USA? Are there any significant differences compared to Russia?

Тема 2.5. Россия в современном мире, Москва, мой родной город.

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

What minerals is Russia rich in? (Oil, gas, coal?)

2. Ответьте на вопрос:

What is the climate like in Siberia? (Cold or hot?)

3. Ответьте на вопрос:

What are the main types of mineral resources that Russia is rich in, and where are they mostly located (e.g., in Siberia)?

4. Ответьте на вопрос:

The climate in Russia is very diverse. How does it differ from the European part to the Far East?

5. Ответьте на вопрос:

Name some of the longest rivers in Russia. What seas do they flow into?

6. Ответьте на вопрос:

If you are from Moscow (or your hometown), what is your favourite place there and why? What makes it special?

Раздел 3. Профессионально-ориентированный иностранный язык

Контролируемые ИДК: УК-4.1 УК-4.2 УК-4.3 УК-4.4 УК-5.1 УК-5.2 УК-5.3 УК-5.4

Тема 3.1. Моя специальность: Современное состояние изучаемой науки, технологии.

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

What is GPS?

2. Ответьте на вопрос:

What modern tools do surveyors (geodesists) use?

3. Ответьте на вопрос:

How has the introduction of GPS/GLONASS technologies changed the profession of a surveyor?

4. Ответьте на вопрос:

What is GIS (Geographic Information System), and what are its main applications in modern life?

5. Ответьте на вопрос:

What are some modern instruments and equipment that geodesists use today instead of traditional theodolites?

6. Ответьте на вопрос:

How are drones (UAVs) used in modern geodesy and cartography?

Тема 3.2. Моя специальность: История изучаемой науки и видные ученые

Форма контроля/оценочное средство: Практическая работа

Вопросы/Задания:

1. Ответьте на вопрос:

Did people make maps long ago?

2. Ответьте на вопрос:

How did sailors find their way before GPS?

3. Ответьте на вопрос:

Who is considered to be the "father of geography" in Ancient Greece, and what was his major work?

4. Ответьте на вопрос:

Can you name a famous Russian scientist who made a significant contribution to the development of geodesy or cartography (e.g., in the exploration of Siberia)?

5. Ответьте на вопрос:

Can you name a famous Russian scientist who made a significant contribution to the development of geodesy or cartography (e.g., in the exploration of Siberia)?

6. Ответьте на вопрос:

What role did the Great Northern Expedition (18th century) play in the mapping of Russia?

Форма контроля/оценочное средство: Контрольная работа

Вопросы/Задания:

1. Translate the text

Engineering preparation surveys

Engineering preparation surveys are a critical component of project development, especially in large-scale construction, infrastructure, or industrial projects. They serve as a foundational step to ensure that all engineering considerations are thoroughly addressed before commencing detailed design and construction activities.

These surveys involve comprehensive assessments of the site and surrounding environment to gather vital data that influence engineering decisions. This includes topographical surveys to understand the terrain and landscape features, geotechnical investigations to evaluate soil and rock properties, and environmental surveys to identify potential ecological impacts. Additionally, utility surveys may be conducted to map existing infrastructure such as water, sewer, electrical, and communication lines, ensuring that future developments do not interfere with existing services.

The purpose of conducting these surveys is to identify potential challenges early in the project lifecycle. By understanding the site's physical and environmental conditions, engineers can develop more accurate designs, estimate costs more precisely, and plan construction methodologies effectively. This proactive approach minimizes risks associated with unforeseen site conditions, reduces delays, and helps in achieving project safety and sustainability goals.

Furthermore, engineering preparation surveys facilitate compliance with regulatory requirements and environmental standards. They provide the necessary data to obtain permits and approvals, ensuring that the project aligns with legal and environmental frameworks. The insights gained from these surveys also enable engineers to optimize design solutions, such as adjusting foundation types based on soil stability or modifying layout plans to mitigate environmental impacts.

In summary, engineering preparation surveys are indispensable for laying the groundwork for successful project execution. They encompass detailed investigations into the physical, geological, and environmental aspects of the site, providing engineers with the critical information needed to design safe, efficient, and compliant infrastructure. Proper execution of these surveys ultimately

contributes to cost savings, risk mitigation, and the overall sustainability of the project.

2. Answer the question: What does the science of history of architecture study?

1. Architecture development process in connection with the biological processes
2. The relationship between people and animals
3. Architecture development process in connection with the historical processes

3. Complete the sentence using the correct word: '_____ is your address?'

1. What
2. How
3. That

4. Choose the correct answer 'Do you speak Japanese? No, I _____'

1. speaking not
2. speak not
3. don't

5. Pick up the correct word: 'a person or company, responsible for the physical construction of a building is _____'

1. scientist
2. constructor
3. doctor

6. Answer the question: What do we call: "a thin tall structure usually rising above the castle or building that it is attached to?"

1. tower
2. table
3. tree

7. Answer the question: "What do modal verbs show?"

1. modality
2. time
3. voice

8. Choose the correct sentence:

1. I am a student.
2. A student I am.
3. A student am I.

9. Answer the question: "When was the University of Geodesy and Cartography founded?"

1. 1779
2. 1920
3. 2000

10. Give the correct translation to the sentence: "This issue must be discussed "

1. Эту проблему не надо обсуждать.
2. Эту проблему необходимо обсудить.
3 Эту проблему нельзя обсуждать.

11. Choose the correct translation to the sentence: Students must take exams in January.

1. Студенты должны сдавать экзамены в январе.
2. Студентам не надо сдавать экзамены в январе.
3 Студенты хотят сдавать экзамены в январе.

7. Оценочные материалы промежуточной аттестации

1-я летняя сессия, Экзамен

Контролируемые ИДК: УК-4.1 УК-5.1 УК-4.2 УК-5.2 УК-4.3 УК-5.3 УК-4.4 УК-5.4

Вопросы/Задания:

1. Translate the text. (1800 printed characters; time – 45 min.)

Engineering Geodetic Support: The Critical Pre-Construction Phase

Definition: Engineering Geodetic Support (EGS) is the systematic application of precise geodetic and surveying techniques throughout the lifecycle of engineering projects. Its primary goal is to ensure the spatial accuracy, safety, quality, and compliance of constructed objects and infrastructure, from initial planning through construction, operation, and monitoring.

The pre-construction phase of Engineering Geodetic Support (EGS) constitutes the indispensable foundation upon which the entire success, safety, and precision of any major construction project rests. It encompasses a meticulously planned and executed series of geodetic and surveying activities designed to transform abstract design concepts into a spatially accurate and physically actionable reality on the ground. This phase is not merely preparatory; it is the bedrock of spatial control, risk mitigation, and informed decision-making for all subsequent construction stages.

The primary objective of pre-construction EGS is the establishment of a high-precision, reliable, and project-specific geodetic control network. This network serves as the absolute spatial reference framework for all project activities. Establishing this control begins with extensive reconnaissance to identify optimal locations for permanent and temporary control points, considering factors like inter-visibility, stability, security, and avoidance of construction activity impacts. Utilizing advanced Global Navigation Satellite Systems (GNSS), including GPS, GLONASS, Galileo, and BeiDou, in static or real-time kinematic (RTK) modes, surveyors determine the precise three-dimensional coordinates (latitude, longitude, elevation) of these primary control points with millimeter to centimeter-level accuracy relative to national or project-specific datums. This network is densified and extended across the site using high-precision total stations through traversing and triangulation techniques, ensuring consistent accuracy is available wherever layout or verification is needed.

Concurrently, a comprehensive topographic survey is conducted. This involves the detailed mapping of the existing natural and man-made features within and surrounding the project site. Using a combination of GNSS, robotic total stations, terrestrial laser scanning (LiDAR), and increasingly, Unmanned Aerial Vehicles (UAVs or drones) equipped with photogrammetric or LiDAR payloads, surveyors capture millions of data points representing the terrain, vegetation, existing structures, utilities, roads, water bodies, and other relevant features. This massive dataset is processed to generate highly accurate digital terrain models (DTMs), digital surface models (DSMs), contour maps, and detailed site plans. These deliverables provide the essential "as-is" reality against which engineers design the future "to-be" facility, enabling accurate earthwork volume calculations, optimal site planning, identification of potential conflicts or hazards, and environmental impact assessment.

A crucial component often falling under pre-construction EGS is engineering preparation of the territory. This involves the geodetic stakeout and control of significant earthmoving operations. Based on the design grading plans, surveyors precisely mark the limits of clearing and grubbing, locations for cut and fill, proposed slopes, and drainage channels. They establish temporary benchmarks and grids specifically for earthwork contractors. Crucially, geodetic personnel perform regular monitoring and volume calculations during mass earthworks, verifying that the site is being shaped according to design specifications and providing data for progress payments. This ensures the site is physically prepared for the commencement of structural construction.

Finally, the initial layout or stakeout work marks the tangible transition from design to physical implementation. Using the established control network and design coordinates, surveyors precisely position and mark the fundamental alignment elements of the project on the ground. This includes the primary project axes, building or structure centerlines, baseline grids, major road alignments, key foundation points, pile locations, and primary elevation benchmarks. This initial stakeout provides the essential spatial skeleton that guides all subsequent detailed construction activities, ensuring that the project begins with the correct orientation, position, and scale. The accuracy achieved in this pre-construction phase directly dictates the feasibility, cost-efficiency, and safety of the entire construction process, preventing costly errors, rework, and potential structural failures downstream. It is the geodetic blueprint that transforms engineering vision into buildable reality.

2. Translate the text. (1800 printed characters; time – 45 min.)

Topographic Survey: Capturing the Existing Landscape for Engineering Success

A topographic survey is the fundamental geospatial process of meticulously measuring and mapping the three-dimensional configuration of a specific area of the Earth's surface, encompassing both its natural terrain and the built environment. Its paramount objective is to create an accurate, detailed, and reliable representation of the "as-is" conditions existing before any design or construction activities commence. This critical dataset forms the indispensable spatial foundation upon which engineers, architects, and planners base their designs, perform analyses, calculate volumes, and make informed decisions, directly influencing project feasibility, cost estimation, and execution strategy.

The accurate capture of existing conditions relies on a sophisticated arsenal of geodetic instruments and methodologies, each chosen for its specific strengths in terms of precision, efficiency, coverage, and suitability to the site's characteristics. Global Navigation Satellite Systems (GNSS), utilizing constellations like GPS, GLONASS, Galileo, and BeiDou, provide highly efficient and accurate positioning across vast areas. Real-Time Kinematic (RTK) and Network RTK (NRTK) techniques enable surveyors to establish control points and collect feature positions in real-time with centimeter-level accuracy, even in relatively open terrain. GNSS is particularly invaluable for establishing the primary project control network and capturing scattered features like trees, manholes, or property corners over large sites. Robotic Total Stations (TS) offer unparalleled angular and distance measurement precision for detailed surveys. Operated by a single person, these instruments automatically track a prism, allowing for rapid collection of dense point data for intricate features like building facades, complex structures, curb lines, and precise spot elevations. Total stations excel in areas with limited satellite visibility (urban canyons, dense forests) or where the highest local accuracy is required for critical infrastructure tie-ins.

Terrestrial Laser Scanning (LiDAR) represents a revolutionary leap in data capture density and speed. A scanner rapidly emits millions of laser pulses, measuring distances to create a highly detailed "point cloud" – a massive 3D dataset representing the exact shape and position of everything within its line of sight. This method is exceptionally powerful for capturing complex structures (bridges, industrial plants), irregular terrain features, congested sites, and creating accurate as-built records of existing facilities. It provides an unparalleled level of detail for clash detection and volumetric calculations. Unmanned Aerial Vehicles (UAVs or drones), equipped with high-resolution cameras (for photogrammetry) or increasingly, lightweight LiDAR sensors, offer a transformative perspective. Flying systematic patterns over the site, they capture hundreds or thousands of overlapping aerial images. Through sophisticated photogrammetric processing (Structure from Motion - SfM algorithms), these images are transformed into detailed orthophotos (geometrically corrected aerial maps) and dense 3D point clouds. UAV LiDAR directly captures elevation data through vegetation canopy. Drones provide rapid, safe, and cost-effective coverage of large, inaccessible, or hazardous areas (steep slopes, quarries, pipeline corridors), delivering vast amounts of topographic data efficiently.

The culmination of the topographic survey process is the generation of essential deliverables that translate raw measurements into usable engineering intelligence. The Digital Terrain Model (DTM) is arguably the most crucial output. It represents the bare earth surface, meticulously stripped of all above-ground features like vegetation, buildings, and infrastructure. Generated by filtering point cloud or survey data, the DTM is typically a triangulated irregular network (TIN) or a grid of elevation points. It is the fundamental surface used for earthwork volume calculations, hydrological modeling, slope stability analysis, and designing foundations and grading plans. Complementing the DTM, the Digital Surface Model (DSM) captures the topmost surface visible from above, including trees, buildings, vehicles, and other above-ground features. It is vital for visibility studies, line-of-sight analysis, 3D visualization, and initial solar potential assessments. Traditional contour lines, connecting points of equal elevation, remain a highly intuitive and widely used deliverable. Generated from the DTM, contour maps provide a clear visual representation of the terrain's shape, slope steepness, and drainage patterns, essential for site planning and preliminary design reviews. Finally, comprehensive topographic plans integrate all captured data. These detailed maps, usually CAD or GIS-based, depict the DTM/contours alongside all surveyed natural and man-made features

(buildings, roads, utilities, fences, water bodies, vegetation boundaries), often overlaid on an orthophoto base map. These plans are the primary reference documents for detailed engineering design, permitting, and construction planning, providing the definitive snapshot of pre-project site conditions.

3. Translate the text. (1800 printed characters; time – 45 min.)

Engineering preparation surveys

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These surveys involve comprehensive assessments of the site and surrounding environment to gather vital data that influence engineering decisions. This includes topographical surveys to understand the terrain and landscape features, geotechnical investigations to evaluate soil and rock properties, and environmental surveys to identify potential ecological impacts. Additionally, utility surveys may be conducted to map existing infrastructure such as water, sewer, electrical, and communication lines, ensuring that future developments do not interfere with existing services.

The purpose of conducting these surveys is to identify potential challenges early in the project lifecycle. By understanding the site's physical and environmental conditions, engineers can develop more accurate designs, estimate costs more precisely, and plan construction methodologies effectively. This proactive approach minimizes risks associated with unforeseen site conditions, reduces delays, and helps in achieving project safety and sustainability goals.

Furthermore, engineering preparation surveys facilitate compliance with regulatory requirements and environmental standards. They provide the necessary data to obtain permits and approvals, ensuring that the project aligns with legal and environmental frameworks. The insights gained from these surveys also enable engineers to optimize design solutions, such as adjusting foundation types based on soil stability or modifying layout plans to mitigate environmental impacts.

In summary, engineering preparation surveys are indispensable for laying the groundwork for successful project execution. They encompass detailed investigations into the physical, geological, and environmental aspects of the site, providing engineers with the critical information needed to design safe, efficient, and compliant infrastructure. Proper execution of these surveys ultimately contributes to cost savings, risk mitigation, and the overall sustainability of the project.

4. Translate the text. (1800 printed characters; time – 45 min.)

Geodetic Stakeout for Site Preparation: Enabling Precision in Clearing and Earthworks

The initial transformation of a raw site into a construction-ready platform hinges critically on precise geodetic stakeout and control, specifically targeting site clearing and mass earthworks operations. This phase, executed during pre-construction and early construction, translates complex grading and erosion control plans into tangible markers on the ground, guiding heavy machinery and enabling rigorous verification. It is a fundamental process ensuring the site is shaped according to design intent, laying the literal groundwork for all subsequent structural activities.

The first crucial task is the stakeout for site clearing and grubbing. Based on the project's site development plan and environmental permits, surveyors meticulously mark the boundaries of areas designated for vegetation removal, habitat protection zones, and any existing structures slated for demolition. This involves establishing clear, unambiguous lines on the terrain. Typically, this is achieved by setting a series of closely spaced stakes or brightly colored flags along the defined perimeter. Robust wooden hubs or durable plastic markers are often used at key turning points and intersections. Accompanying these physical markers are detailed alignment sheets provided to the earthwork contractor, clearly indicating coordinates, offsets, and the required clearance width. This precision prevents unauthorized encroachment into protected areas, minimizes unnecessary environmental disturbance, and ensures only the exact footprint required for construction is cleared, optimizing both cost and ecological compliance.

Simultaneously, geodetic teams establish the essential horizontal and vertical control framework specifically tailored for earthmoving operations. This involves setting a dense network of temporary benchmarks (TBM) across the site, strategically located for easy access by equipment operators and surveyors, yet placed outside active work zones to avoid destruction. These TBMs provide reliable elevation references. Additionally, a simplified but robust horizontal grid or alignment system is often established, tied directly to the project's primary control network. This localized grid simplifies communication and layout for the earthwork crew, allowing them to quickly reference stakes defining cut/fill slopes, drainage swales, and temporary access roads. The stability and accuracy of this temporary control system are paramount, as it forms the basis for all subsequent measurements and machine guidance during the earthworks phase.

The core of geodetic support for mass earthworks lies in staking the design landform. This involves marking the critical lines and points that define the final designed grades and slopes. Surveyors precisely position and mark:

Limit of Work Lines: Defining the overall extents of excavation and embankment areas.

Catch Points / Slope Stakes: Placed along proposed cut and fill slopes. These stakes are clearly labeled with essential information: the station (location along the alignment), the offset distance from a baseline, the existing ground elevation, the design elevation at that specific point, and crucially, the "cut" or "fill" depth required (e.g., "C 2.15m" or "F 1.80m"). This tells equipment operators exactly how much material to remove or add at that precise location to achieve the design slope.

Toe of Slope and Top of Slope Lines: Clearly marking where slopes begin and end.

Drainage Features: Staking the centerlines, flowlines, and top edges of ditches, swales, culverts, and sediment basins.

Borrow Areas and Stockpiles: Defining locations for material extraction and temporary storage, including volume control markers.

Temporary Access Roads: Ensuring safe and efficient movement of machinery across the site.

Beyond initial staking, ongoing volume calculation and control are vital geodetic functions. Before major earthmoving begins, an accurate pre-construction topographic survey provides the baseline surface model (DTM). As work progresses, surveyors conduct periodic topographic surveys – increasingly using drones (UAVs) for rapid and extensive coverage – to capture the current ground surface. Comparing the current DTM to the pre-construction DTM and the final design DTM allows for precise calculation of cut and fill volumes moved during specific periods. This data is essential for several reasons: Progress Tracking: Quantifying work completed against the project schedule. Payment Certification: Providing objective measurements for contractor payments based on actual quantities of material moved. Design Verification: Identifying any significant deviations from the planned grades early, allowing for corrective action before they become costly problems. Balance Analysis: Determining if sufficient suitable material is being generated from cuts to meet the needs of fills, or if import/export is required. This continuous feedback loop, driven by accurate geodetic measurement, ensures the earthwork phase stays on budget, on schedule, and crucially, achieves the design surface accuracy necessary for the safe and proper construction of foundations, slabs, pavements, and underground utilities.

5. Translate the text. (1800 printed characters; time – 45 min.)

As-built surveys

An As-built survey is a detailed documentation process that captures the exact positions, dimensions, and features of a constructed project once it is completed. Its primary purpose is to provide an accurate record of the as-constructed conditions, reflecting any deviations or modifications from the original design plans. This information is crucial for future maintenance, repairs, renovations, or legal documentation, ensuring that stakeholders have a precise understanding of the existing infrastructure.

The methods employed in conducting an As-built survey vary depending on the project scope and complexity. Traditional approaches often involve manual measurements using tape measures, levels, and theodolites to gather data on key features and boundaries. In recent years, technological advancements have led to the adoption of more sophisticated techniques such as terrestrial laser scanning (TLS), photogrammetry, and drone-based aerial surveys. These methods can quickly capture large and complex areas with high precision, reducing the time and labor involved.

The equipment used in As-built surveys encompasses a range of tools, including total stations, laser scanners, GPS receivers, digital cameras, and drones equipped with high-resolution cameras and LiDAR sensors. Total stations allow for precise angular and distance measurements, essential for detailed point cloud generation and feature positioning. Laser scanners produce dense point clouds that represent the surveyed environment in three dimensions, enabling detailed modeling of structures and terrain. GPS receivers are used for georeferencing the survey data, especially in large outdoor projects, while drones facilitate rapid data collection over inaccessible or expansive areas.

In summary, As-built surveys are vital for accurately capturing the final constructed conditions of a project, employing advanced measurement techniques and equipment to ensure high precision and comprehensive documentation. They support effective project management, facilitate future modifications, and serve as legal records of the constructed infrastructure.

6. Translate the text. (1800 printed characters; time – 45 min.)

Geometric control: Verifying alignment, elevation, verticality, and dimensions of built elements

Geometric control is a fundamental aspect of construction and architectural verification that ensures built elements conform accurately to design specifications. It involves a comprehensive process of verifying the precise alignment, elevation, verticality, and dimensions of various structural and architectural components to guarantee the integrity, safety, and aesthetic quality of a construction project.

The process begins with establishing a reliable reference framework, often through the use of control points and benchmarks that are accurately positioned and measured on-site. These control points serve as the foundational coordinates from which the entire building or structure is measured and monitored. Using sophisticated surveying tools such as total stations, laser scanners, and GPS devices, engineers and surveyors meticulously measure the positions of key elements relative to these control points.

Verifying alignment involves checking that walls, beams, columns, and other structural elements run true to their intended paths. This ensures that elements are straight and follow the designed axes, which is crucial for the structural stability and the proper functioning of the building. Elevation verification confirms that each element is positioned at the correct height, maintaining consistent levels throughout the structure. This is vital for aspects such as floor heights, ceiling levels, and the placement of windows and doors, all of which must align precisely to facilitate seamless construction and functional use.

Verticality verification ensures that columns, walls, and other load-bearing elements are perfectly upright, preventing structural issues such as leaning or buckling. Achieving verticality typically involves using plumb lines, laser plummets, or electronic inclinometers to detect deviations from the true vertical. Dimensions verification, on the other hand, involves measuring the sizes, distances, and angles of built elements to confirm they match the detailed drawings and specifications. This includes checking lengths, widths, depths, and inter-element distances, and is often carried out with tape measures, calipers, or laser distance meters.

Throughout this process, any discrepancies or deviations identified are documented and addressed promptly. Corrections may involve re-aligning elements, adjusting elevations, or making precise modifications to ensure compliance with the design intent. This rigorous verification process not only helps in maintaining the quality and safety standards but also minimizes costly rework and delays during construction.

In essence, geometric control acts as a quality assurance mechanism that bridges the gap between the design and the constructed reality. It ensures that every component of the built environment aligns perfectly with the original plans, preserving the integrity of the architectural vision and contributing to the durability and aesthetic appeal of the final structure.

7. Translate the text. (1800 printed characters; time – 45 min.)

Construction phase: Volume calculations: Monitoring earthworks, materials (e.g., concrete)

Engineering Geodetic Support (EGS) is the systematic application of precise geodetic and surveying techniques throughout the lifecycle of engineering projects. Its primary goal is to ensure the spatial

accuracy, safety, quality, and compliance of constructed objects and infrastructure, from initial planning through construction, operation, and monitoring.

During the construction phase, volume calculations play a crucial role in ensuring the project progresses efficiently, accurately, and within budget. Monitoring earthworks involves precisely measuring the amount of soil or other materials excavated or filled to meet the project's design specifications. This process typically requires detailed volume calculations derived from survey data, CAD drawings, and site measurements. Accurate volume assessments help in planning the procurement and transportation of materials, preventing shortages or excesses that could lead to delays or increased costs.

In the case of materials like concrete, volume calculations are essential for determining the correct quantities needed for various structural elements such as foundations, beams, slabs, and other components. These calculations are based on the dimensions provided in the engineering drawings, taking into account the shape, thickness, and reinforcement details. Precise measurement ensures that the right amount of concrete is produced, minimizing waste and optimizing resource utilization. During construction, these calculations are verified through on-site sampling and measurements, ensuring that the poured quantities match the planned volumes.

Monitoring earthworks and material quantities also involves continuous tracking and updating of volume data throughout the construction process. This can be facilitated through technologies such as 3D laser scanning, drone surveys, and digital modeling, which provide real-time data and help identify any discrepancies early on. This ongoing monitoring allows project managers to make informed decisions regarding resource allocation, scheduling, and cost control, ultimately contributing to the successful completion of the project within its designated parameters.

8. Translate the text. (1800 printed characters; time – 45 min.)

Geodetic Supervision: The Guardian of Spatial Integrity in Construction

Geodetic supervision represents the critical, proactive, and continuous oversight function performed by qualified surveying personnel throughout the active construction phase. It transcends the execution of discrete surveying tasks like stakeout or as-built verification; instead, it embodies the persistent vigilance required to ensure that every aspect of the built structure conforms precisely to the approved design plans, specifications, and spatial tolerances. This ongoing process acts as the essential geospatial quality assurance mechanism, safeguarding against deviations that could lead to costly rework, delays, safety hazards, or functional failures later in the project lifecycle or during operation.

The core principle of geodetic supervision is its continuous presence and proactive engagement. Supervising surveyors are not merely reactive, arriving only when called for a specific layout. They are embedded within the construction workflow, maintaining a constant awareness of ongoing activities. This involves regular site walks, direct communication with construction managers, foremen, and crews, and a deep understanding of the construction sequence. By being present, they anticipate upcoming critical stages requiring geodetic verification (e.g., prior to concrete pours for foundations, setting critical equipment, or welding major pipeline segments) and ensure surveying support is timely and accurate. They actively monitor workmanship, observing how contractors interpret and implement staked points or benchmarks, intervening immediately if practices are observed that could compromise accuracy, such as relying solely on string lines without verification, disturbing control points, or inadequate protection of survey markers.

A key function is the systematic verification of constructed elements against design. This goes beyond formal as-built surveys. It involves frequent, targeted checks at critical junctures: confirming the position and elevation of reinforcing steel cages before concrete placement; verifying the alignment and grade of freshly laid pipelines before backfilling; checking the plumb and position of structural steel columns after erection but before bracing or cladding; ensuring the correct positioning of anchor bolts embedded in foundations. These interim verifications catch discrepancies early, when corrections are still feasible and relatively inexpensive. Supervising surveyors meticulously compare field measurements directly to the design coordinates and elevations, documenting any deviations and ensuring they are either within acceptable tolerance limits or promptly rectified.

Geodetic supervision also encompasses rigorous control network management. Supervising personnel are responsible for the ongoing integrity and availability of the project's geodetic control

points. This includes regularly checking the stability of primary and secondary control monuments, re-establishing points if disturbed or destroyed by construction activity, and verifying the calibration and performance of surveying instruments used by both the supervision team and, where applicable, contractor survey teams. They maintain a central log of all control points, their status, and any adjustments made, ensuring consistency and traceability of all spatial data throughout the project. Furthermore, supervision involves meticulous documentation. Every verification check, intervention, identified deviation, corrective action taken, and control point status update is formally recorded. Daily logs, inspection reports, and non-conformance reports (NCRs) provide a real-time audit trail. This comprehensive documentation is vital for quality assurance records, resolving potential disputes, supporting payment applications based on completed work meeting specifications, and creating the foundation for the final, authoritative as-built documentation. Ultimately, geodetic supervision is the indispensable layer of geospatial governance that transforms design intent into physical reality with precision and accountability, minimizing risk and maximizing project success.

9. Translate the text. (1800 printed characters; time – 45 min.)

Deformation Monitoring: Safeguarding Infrastructure Through Precise Measurement of Movement

Deformation monitoring is a critical, systematic geodetic process dedicated to detecting, measuring, and analyzing the displacement, settlement, tilt, vibration, or strain experienced by engineered structures, their foundations, and the surrounding ground mass over time. It transcends simple surveying; it is an essential engineering safeguard, providing quantitative data on structural behavior to ensure operational integrity, verify design assumptions, predict potential failure modes, and trigger timely maintenance or intervention before minor movements escalate into catastrophic failures. This ongoing vigilance is paramount for high-consequence infrastructure where stability is non-negotiable, such as dams, nuclear power plants, bridges, high-rise buildings, offshore platforms, historical monuments, slopes adjacent to critical facilities, and extensive pipeline networks.

The fundamental objective is to establish a reliable baseline of the structure's or ground's initial position and geometry immediately after construction or at the commencement of monitoring. This baseline is established using highly precise geodetic techniques, creating a network of stable reference points located outside the anticipated zone of influence and a network of monitoring points (targets, prisms, sensors) strategically attached to or embedded within the structure itself or installed in the ground. The selection of monitoring point locations is based on engineering judgment, structural analysis (identifying critical points like maximum bending moments, potential hinge points, zones of differential settlement), and the specific failure mechanisms being assessed (e.g., sliding, overturning, settlement, heave).

Measurement campaigns are then conducted at defined intervals throughout the asset's operational life, ranging from continuous real-time surveillance to monthly, quarterly, or annual surveys, dictated by the structure's criticality, its age, observed behavior, environmental loading factors, and regulatory requirements. Continuous monitoring is often employed for exceptionally high-risk structures like large dams or nuclear facilities, utilizing permanently installed, automated sensors providing data streams 24/7. Periodic monitoring involves repeated measurements using precise instruments at specific times. The core suite of technologies deployed is diverse, each suited to specific movement types and accuracies: High-Precision Geometric Leveling remains the gold standard for detecting vertical movements (settlement, heave) with sub-millimeter accuracy over short to medium distances, comparing elevations of monitoring points to stable benchmarks. Robotic Total Stations (often automated – ATMS) continuously or periodically measure precise horizontal angles and distances to prisms mounted on the structure, capable of detecting minute horizontal displacements and tilts in multiple axes. Global Navigation Satellite Systems (GNSS) provide continuous, all-weather, 3D positioning (latitude, longitude, elevation) for monitoring points on large structures (dams, bridges, platforms) or in remote areas, achieving centimeter to millimeter-level accuracy with sophisticated processing. Terrestrial Laser Scanning (LiDAR) captures dense 3D point clouds of the entire structure or slope surface at different epochs, enabling comprehensive visualization and quantification of deformation patterns, crack propagation, or surface changes through comparison. Inclinometers (in-place or traversing) measure lateral deformation profiles deep within boreholes in soil or rock, critical for assessing slope stability or deep-seated foundation movements. Piezometers monitor pore water pressure changes, a key driver of ground movement. Interferometric Synthetic

Aperture Radar (InSAR), utilizing satellite or ground-based radar, detects ground surface deformation over vast areas with millimeter precision, invaluable for regional subsidence studies or monitoring ground stability around large industrial sites.

The true value lies not just in collecting data, but in its rigorous processing, analysis, and interpretation. Time-series analysis is performed on the measured coordinates or displacements of each monitoring point, plotting movement against time and correlating it with potential triggers like reservoir level changes in dams, seasonal temperature fluctuations, heavy rainfall, seismic events, or nearby construction activities. Advanced statistical methods and deformation modeling are used to distinguish between normal elastic behavior (reversible movement under load) and concerning inelastic creep or progressive failure. Threshold alarm levels are predefined; exceeding these triggers immediate engineering assessment. The output is comprehensive deformation reports detailing movement vectors, rates, accelerations, and potential causes, providing actionable intelligence for asset managers and engineers to make informed decisions regarding structural health, required maintenance, safety protocols, or the necessity for major reinforcement. Ultimately, deformation monitoring is the indispensable geodetic sentinel, providing the empirical evidence needed to manage risk, extend asset lifespan, and protect lives, property, and the environment by ensuring structures stand firm against the test of time and load.

10. Translate the text. (1800 printed characters; time – 45 min.)

Geodetic Support for Modifications, Repairs, and Expansions: Enabling Precise Infrastructure Evolution

The operational lifecycle of critical oil & gas and energy infrastructure is characterized not by static existence, but by continuous adaptation. Retrofits to enhance efficiency or comply with new regulations, expansions to increase capacity, and essential repairs to maintain integrity all demand precise spatial integration with the existing facility. Engineering geodetic support is the indispensable enabler of these complex interventions, providing the accurate geospatial data and precise positioning necessary to execute modifications safely, efficiently, and without disrupting ongoing operations. This function transforms abstract engineering change orders into actionable, millimeter-accurate field work within the intricate, often congested, and potentially hazardous environment of a live industrial complex.

The foundation for successful modification or repair support lies in accessing and verifying accurate as-built geospatial data. Ideally, comprehensive "as-built" surveys and documentation from the original construction phase exist within a facility's Geographic Information System (GIS) or Building Information Model (BIM). Geodetic personnel retrieve and validate this data, ensuring it reflects the true current state of the facility. However, for older infrastructure or where documentation is incomplete or unreliable, the first critical step becomes conducting a targeted verification survey. This involves using precise techniques like terrestrial laser scanning (LiDAR) to capture dense 3D point clouds of the specific area affected by the planned work, or employing robotic total stations and GNSS to survey critical existing structures, equipment foundations, piping isometrics, and structural elements. This survey establishes the definitive spatial context into which the new element must integrate, identifying any discrepancies between design records and physical reality.

Armed with verified existing conditions and the modification design, geodetic support shifts to detailed planning and precise layout. For a retrofit, this might involve calculating the exact position for new equipment foundations relative to existing structural columns and pipe racks, ensuring adequate clearances for operation and maintenance. For a pipeline repair or tie-in, it requires determining the precise cut points on the existing line and the positioning of the replacement spool or new valve assembly to achieve perfect flange alignment. For an expansion, it entails extending the facility's control network into the new area and staking the exact location of new structural foundations tied seamlessly to the existing grid. Surveyors meticulously calculate coordinates and elevations for every critical interface point – anchor bolt patterns, pipe weld joints, structural connection plates, conduit penetrations – often requiring complex spatial calculations to navigate around obstructions and adhere to stringent tolerances. This planning phase is crucial for clash detection, ensuring the new components fit within the spatial envelope without interfering with existing infrastructure.

During the execution phase, geodetic personnel perform high-precision stakeout and real-time

guidance. This involves setting out the calculated points directly in the field with millimeter-level accuracy using robotic total stations or GNSS. For critical operations like cutting into a live pipeline under controlled conditions, surveyors provide continuous positioning feedback to the technicians, ensuring the cut is made exactly at the designated point. When setting new heavy equipment, surveyors guide the precise placement onto foundation bolts or sole plates. During structural steel erection for an expansion, they verify column plumbness and alignment to ensure seamless connection to the existing framework. This on-site support is vital in confined or hazardous spaces where visual alignment is impossible and tolerances are tight, preventing costly errors, rework, and potential safety incidents. Furthermore, temporary monitoring may be deployed during critical lifts or structural modifications to detect any unintended movement of adjacent structures or equipment that could pose a risk.

Finally, geodetic support ensures accurate as-built documentation of the modified state. Once the modification, repair, or expansion is complete, surveyors conduct a final verification survey. This captures the precise location and geometry of all newly installed components and their interfaces with the existing infrastructure. This updated geospatial data is then integrated back into the facility's GIS and/or BIM, ensuring the digital twin accurately reflects the current physical asset. This updated record is essential for future operations, maintenance planning, subsequent modifications, regulatory compliance audits, and overall asset integrity management. By providing this continuous thread of precise spatial information from assessment through execution to documentation, geodetic support is the silent guardian of precision, safety, and long-term operability as vital energy infrastructure evolves throughout its decades-long service life.

11. Translate the text. (1800 printed characters; time – 45 min.)

Subsidence Monitoring: Safeguarding Assets and Environment in Extractive Regions

Subsidence monitoring represents a critical, specialized facet of geodetic engineering focused on the precise measurement and analysis of ground settlement over extensive areas and extended time periods. While settlement can occur naturally or due to urban development, it becomes a paramount engineering concern in regions affected by subsurface resource extraction, particularly mining (both surface and underground) and oil & gas production (including conventional reservoirs and unconventional shale plays). In these contexts, the removal of vast volumes of solid minerals, fluids (oil, gas, water), or the creation of subsurface voids fundamentally alters the geomechanical equilibrium, leading to compaction of reservoir rocks or collapse/arching of overlying strata, ultimately manifesting as measurable ground surface displacement. The consequences of uncontrolled or unmonitored subsidence can be severe, ranging from structural damage to critical infrastructure, disruption of surface drainage, environmental harm (wetland loss, saltwater intrusion), and threats to public safety, making systematic monitoring an indispensable component of responsible resource development and long-term risk management.

The fundamental objective is to detect, quantify, and understand the spatial extent, magnitude, rate, and evolution of ground settlement induced by extraction activities. This requires establishing a robust geodetic monitoring network before significant extraction begins to capture the pre-subsidence baseline conditions. This network consists of a stable reference framework located outside the anticipated zone of influence (using deep-benchmarked monuments or GNSS base stations on bedrock) and a dense array of monitoring points distributed across the area of potential impact. Monitoring points can be traditional survey monuments, rod extensometers anchored at depth, or strategically placed prisms. Crucially, the network design must anticipate the potentially vast spatial scale (tens to hundreds of square kilometers) and the slow, often non-linear, temporal nature of subsidence, which can continue for years or even decades after extraction ceases.

Advanced geodetic technologies are deployed to capture the complex subsidence phenomena. Synthetic Aperture Radar Interferometry (InSAR), particularly time-series analysis of satellite radar data (e.g., Sentinel-1, TerraSAR-X), has revolutionized subsidence monitoring. It provides near-continuous, millimeter-accurate measurements of vertical displacement over enormous areas, generating detailed subsidence "bowl" maps that reveal spatial patterns and rates. High-Precision GNSS (Continuous Operating Reference Stations - CORS) installed at critical locations provide continuous, absolute 3D positioning data, validating InSAR measurements and capturing horizontal movements often associated with subsidence bowls. Robotic Total Stations periodically measure precise positions of surface prisms within targeted high-risk zones or near specific infrastructure.

Precise Geometric Leveling remains essential for establishing the highest vertical accuracy reference framework and validating other techniques along key profiles. Extensometers, installed in deep boreholes, directly measure compaction occurring within specific subsurface strata, differentiating between reservoir compaction and overburden sagging. LiDAR (Airborne or Terrestrial) and Photogrammetry (UAV-based) provide high-resolution topographic data at different epochs, enabling detailed change detection analysis of surface features, slopes, and infrastructure.

The true power lies in integrating geodetic measurements with subsurface data. Monitoring data is meticulously correlated with detailed extraction records: volumes and locations of mined coal or ore, volumes and pressures of produced fluids, locations of injection wells (for enhanced oil recovery or wastewater disposal, which can also induce surface deformation), and the timing of these activities. Sophisticated geomechanical models are calibrated and refined using the measured subsidence data. These models aim to predict future subsidence behavior based on planned extraction, identify areas at highest risk, and assess potential impacts on surface features. Key parameters derived include the subsidence extent, the maximum magnitude of settlement, the subsidence rate, and the location of the point of maximum subsidence. Critically, monitoring tracks differential settlement – where adjacent points settle at different rates – as this is the primary cause of damage to pipelines, roads, railways, buildings, and dams.

The outputs drive critical risk mitigation and operational decisions. Early Warning Systems: Real-time or near-real-time monitoring (via GNSS CORS or automated total stations) can trigger alerts if subsidence rates exceed safe thresholds near critical infrastructure. Infrastructure Protection: Data informs the design of protective measures for pipelines (e.g., installing flexible joints, targeted soil stabilization), reinforcement of structures, or rerouting of planned infrastructure. Regulatory Compliance & Liability Management: Comprehensive monitoring provides objective evidence for regulatory reporting, demonstrating responsible operations and managing potential liability claims for surface damage. Reservoir Management: In oil/gas, surface subsidence data can be an indirect indicator of reservoir compaction, informing decisions on injection strategies to maintain pressure and optimize recovery. Environmental Impact Assessment: Monitoring quantifies impacts on wetlands, coastlines, and groundwater regimes, guiding remediation efforts. Ultimately, subsidence monitoring in mining and hydrocarbon regions is not merely observational; it is a proactive geotechnical safeguard. By providing empirical, quantitative data on the ground's response to extraction, it enables operators, regulators, and communities to understand the risks, implement effective mitigation strategies, minimize environmental damage, protect vital infrastructure, and ensure the long-term safety and sustainability of operations in these geodynamically active landscapes.

12. Translate the text. (1800 printed characters; time – 45 min.)

Engineering Geodetic Support: The Technological Arsenal for Precision and Insight

The effectiveness of Engineering Geodetic Support (EGS) hinges on a sophisticated and continually evolving suite of methods and technologies. These tools transform theoretical designs into physical reality with millimeter precision, monitor structural health over decades, and provide the critical geospatial intelligence needed for safe, efficient, and compliant construction and operation of complex infrastructure. This technological foundation integrates classical surveying principles with cutting-edge digital innovations to meet the demanding spatial challenges of modern engineering projects.

At the core of precise positioning and control lie Global Navigation Satellite Systems (GNSS), leveraging constellations like GPS, GLONASS, Galileo, and BeiDou. Modern high-precision GNSS techniques, particularly Real-Time Kinematic (RTK) and Network RTK (NRTK), provide centimeter-level accuracy in real-time for establishing control networks, stakeout, and positioning across vast sites or remote locations. Post-Processed Kinematic (PPK) and Precise Point Positioning (PPP) techniques extend this capability to offshore platforms or areas with limited communication. GNSS is indispensable for large-scale linear projects (pipelines, transmission lines), deformation monitoring networks, and establishing fundamental project datums. Complementing GNSS for localized, ultra-high precision are Robotic Total Stations (RTS). These instruments automate angle

and distance measurement, allowing a single operator to conduct precise layout (stakeout), as-built surveys, and deformation monitoring with exceptional speed and accuracy. Their ability to automatically track a prism enables efficient data collection for complex structures, critical equipment placement, and monitoring points. Precise Digital and Optical Leveling remains the gold standard for establishing and monitoring vertical control with sub-millimeter accuracy over short to medium distances, essential for foundations, slab elevations, and detecting subtle settlement.

Revolutionizing data capture for as-built documentation, volumetric calculations, and complex site modeling is Terrestrial Laser Scanning (TLS or LiDAR). By emitting millions of laser pulses per second, TLS generates dense, highly accurate 3D point clouds representing the exact shape and position of structures, terrain, and equipment. This technology excels in congested sites, for capturing intricate existing conditions (e.g., within operational plants), verifying complex geometries, performing clash detection, calculating stockpile volumes, and creating detailed digital twins. Extending the reach and perspective is Unmanned Aerial Vehicle (UAV or Drone) Technology. Equipped with high-resolution cameras for photogrammetry or dedicated LiDAR sensors, drones rapidly capture vast amounts of aerial imagery or direct elevation data. Photogrammetric processing using Structure-from-Motion (SfM) algorithms transforms overlapping images into orthophotos, dense point clouds, Digital Surface Models (DSMs), and, after filtering, Digital Terrain Models (DTMs). UAVs are transformative for topographic mapping of large or inaccessible areas, corridor surveys (pipelines, power lines), construction progress monitoring, volumetric calculations, and infrastructure inspection, offering unparalleled efficiency and safety.

For the critical task of long-term structural and ground stability assessment, Automated Deformation Monitoring Systems (ADMS) represent the pinnacle of integration. These systems combine robotic total stations, GNSS sensors, tiltmeters, and other geotechnical instruments (inclinometers, piezometers) into a network of permanently installed sensors. Controlled by central software, they perform continuous, real-time measurements of displacements, tilts, and settlements, transmitting data for immediate analysis and triggering alarms if pre-defined thresholds are exceeded. This is vital for high-risk structures like dams, bridges, nuclear facilities, and slopes. Interferometric Synthetic Aperture Radar (InSAR), utilizing satellite or ground-based radar, provides a powerful wide-area perspective. By analyzing phase differences in radar waves reflected from the ground over time, InSAR detects millimeter-scale ground surface deformation across hundreds of square kilometers, invaluable for monitoring subsidence in mining/oil-gas regions, regional landslide potential, or the stability of large industrial sites. Hydrographic Surveying, employing multibeam and singlebeam echosounders coupled with precise GNSS positioning and inertial measurement units (IMUs), accurately maps underwater terrain, structures, and pipelines, essential for ports, offshore platforms, and underwater cable routes.

Underpinning all these data acquisition methods is the crucial layer of Data Processing, Integration, and Management. Sophisticated Computer-Aided Design (CAD) and Geographic Information System (GIS) software process raw survey data, generate plans and models, manage vast spatial datasets, and support analysis. Building Information Modeling (BIM) represents a paradigm shift, integrating precise geospatial data (from surveys, scans, and monitoring) into intelligent 3D digital models of the facility. This enables clash detection during design, construction simulation, precise component placement, and serves as the foundation for digital twins used throughout the asset lifecycle for facility management and future modifications. Specialized deformation analysis software processes time-series data from monitoring systems, identifying trends, calculating rates, and generating predictive models and alerts. Cloud platforms facilitate data sharing, collaboration, and long-term archival. The seamless integration of these technologies – from field data capture through advanced processing and into intelligent models – creates a powerful, continuous geospatial feedback loop. This loop is fundamental to achieving the core objectives of EGS: ensuring spatial fidelity, safeguarding structural integrity, optimizing processes, and providing the empirical evidence for sound engineering decisions across the entire infrastructure lifecycle.

13. Translate the text. (1800 printed characters; time – 45 min.)

Building Information Modeling (BIM): The Digital Backbone of Modern Infrastructure Lifecycle

Management

Building Information Modeling (BIM) represents a transformative paradigm shift in the design, construction, and management of engineered structures and infrastructure, moving far beyond traditional 2D drafting into a sophisticated, intelligent, and data-rich 3D digital environment. At its core, BIM is a collaborative process centered on the creation and utilization of a dynamic digital representation – the "Information Model" – that encapsulates not only the physical and functional characteristics of a facility but also the vast ecosystem of associated data throughout its entire lifecycle. This model serves as a shared knowledge resource, providing a reliable basis for decisions from earliest conception through demolition, fundamentally changing how projects are planned, built, operated, and maintained. Within the realm of Engineering Geodetic Support (EGS), BIM acts as the critical integrator and amplifier, transforming precise spatial data into actionable intelligence and ensuring geospatial fidelity underpins every phase.

The foundation of a BIM model lies in its intelligent, object-oriented structure. Unlike simple 3D geometry, elements within a BIM model – be it a structural column, a pump, a section of pipe, or an electrical conduit – are defined as intelligent objects. These objects possess inherent attributes ("parameters") such as dimensions, material properties, manufacturer details, performance specifications, cost data, maintenance schedules, and crucially, their precise spatial coordinates and relationships. This intelligence enables automated functions: clash detection identifies spatial conflicts between disciplines (e.g., a pipe running through a structural beam) before construction begins; quantity take-offs generate accurate material schedules; and spatial analysis informs logistics planning. The model evolves dynamically, progressing through distinct levels of detail (LOD), from conceptual massing in early design to fabrication-level precision for complex components.

The synergy between EGS and BIM is profound and multifaceted. Precise geodetic data is the essential spatial anchor that breathes real-world accuracy into the virtual BIM environment. High-accuracy topographic surveys captured via GNSS, terrestrial LiDAR, and drones provide the exact existing conditions upon which the new design is superimposed. During construction, the BIM model guides high-precision stakeout – robotic total stations or GNSS receivers position elements directly according to the model's coordinates. Conversely, as-built surveys, increasingly conducted using laser scanning and photogrammetry, generate dense point clouds that are compared against the design BIM model, verifying construction accuracy and automatically updating the model to reflect reality ("As-Built BIM" or "Asset Information Model"). For complex retrofits or expansions within operational facilities like refineries or power plants, the verified as-built BIM model is indispensable for planning, allowing engineers to virtually position new components within the congested existing environment, ensuring clearances and avoiding clashes before any physical work begins. Deformation monitoring data feeds into the BIM environment, enabling the visualization of structural movements over time within the context of the entire asset.

The true power of BIM unfolds during the operational phase, evolving into a "Digital Twin." This living model, continuously updated with data from sensors, maintenance records, and periodic geodetic surveys (including deformation and subsidence monitoring), becomes the central hub for Facility Management (FM). Operators can visualize the exact location of assets, access maintenance histories and manuals linked to specific equipment objects, plan upgrades using the accurate spatial context, and simulate the impact of changes. Geodetic data, such as subsidence trends affecting pipeline alignments or foundation settlements under critical turbines, is integrated directly, providing spatial context to operational risks and informing predictive maintenance strategies. BIM facilitates spatial queries, energy performance analysis linked to the building fabric, and optimized space utilization. Ultimately, it provides a comprehensive, spatially accurate digital record essential for regulatory compliance, safety management, and future major interventions.

BIM is not merely a technology but a collaborative methodology demanding standardized processes (like ISO 19650) and open data exchange formats (such as IFC - Industry Foundation Classes). Its implementation requires a cultural shift towards shared data ownership and integrated project delivery. The benefits, however, are substantial: significant reductions in errors and rework during construction through clash detection and precise layout; enhanced cost and schedule predictability; improved facility performance and energy efficiency during operation; extended asset lifespan through informed maintenance; and robust data management supporting sustainability goals and decommissioning planning. By seamlessly integrating the precision of engineering geodesy with

intelligent object modeling and rich data, BIM establishes a continuous digital thread, transforming how we create, manage, and sustain the built environment.

14. Translate the text. (1800 printed characters; time – 45 min.)

Accuracy and Safety: The Uncompromising Pillars of Engineering Geodetic Support

Engineering Geodetic Support (EGS) transcends mere measurement; it is a fundamental safeguarding discipline underpinning the entire lifecycle of critical infrastructure. At its heart lie two inseparable and non-negotiable core aims: Spatial Accuracy and Operational Safety. These are not parallel goals but intrinsically linked imperatives, where precision in measurement directly translates into the prevention of catastrophic failures and the protection of human life, the environment, and vast capital investments.

Spatial Accuracy is the bedrock upon which EGS stands. It demands millimeter-to-centimeter level precision in positioning, alignment, elevation, and dimension throughout every project phase. This unwavering commitment to exactitude begins with the establishment of robust, high-precision geodetic control networks that serve as the project's spatial backbone. During construction, meticulous stakeout ensures foundations are poured, structures are erected, and pipelines are laid precisely according to design coordinates and tolerances. Complex components fit seamlessly, machinery aligns perfectly, and interfaces connect without compromise. Accurate as-built surveys capture the constructed reality, forming the reliable baseline for future operations and modifications. In deformation monitoring, the detection of minuscule movements – shifts invisible to the naked eye – relies on instrumentation and methodologies capable of discerning millimeter-level changes over time. This relentless pursuit of accuracy is not an abstract ideal; it is the practical necessity that prevents misaligned flanges causing leaks, ensures turbine shafts rotate true, guarantees bridge bearings seat correctly, and verifies that nuclear containment structures meet their exacting geometric specifications. Even minor deviations, if undetected, can propagate into major structural instabilities, functional impairments, or hazardous malfunctions.

Operational Safety is the paramount outcome enabled by this foundational accuracy. EGS acts as a continuous, vigilant guardian against spatial risks. During construction, precise layout and constant geodetic supervision prevent errors that could lead to crane collisions, structural instability during erection, or accidental utility strikes. Accurate earthwork calculations and slope staking prevent embankment failures or unintended excavations compromising adjacent structures. Most critically, EGS safeguards the long-term integrity of operational assets through systematic deformation and subsidence monitoring. By detecting abnormal settlement of a dam abutment, tilt in a power plant cooling tower, subsidence beneath a pipeline, or movement in a refinery slope before it reaches critical levels, EGS provides the vital early warning needed for preventative intervention. This proactive identification of spatial anomalies allows engineers to assess risks, implement reinforcements, or initiate controlled shutdowns, thereby averting potential disasters like structural collapses, pipeline ruptures, or containment breaches. Furthermore, accurate as-built data and BIM models are essential for safe maintenance and modifications within complex, potentially hazardous operational environments like offshore platforms or chemical plants, ensuring work is planned and executed with full knowledge of spatial constraints and clearances. The precise positioning data integrated into pipeline integrity management systems directly supports leak detection and prevention strategies. Ultimately, the spatial integrity verified and maintained by EGS is the bedrock upon which the physical safety of personnel, surrounding communities, and the environment rests. In the high-stakes world of energy and infrastructure, where failure carries immense consequences, the millimeter precision of EGS is the first and most crucial line of defense, transforming geospatial data into an indispensable shield protecting lives and assets.

15. Translate the text. (1800 printed characters; time – 45 min.)

Quality Control: The Geodetic Guarantee of Constructed Excellence

Within the intricate process of building and maintaining critical infrastructure, Engineering Geodetic Support (EGS) serves as the indispensable, objective arbiter of spatial quality. Its fundamental role extends far beyond simple measurement; EGS is the rigorous quality control mechanism that ensures every element of a structure – from its deepest foundations to its highest structural members, from

kilometers of pipeline to precisely aligned machinery – is built exactly as designed, conforms to stringent specifications, and possesses the inherent geometric integrity required for safe, efficient, and long-lasting operation. This relentless pursuit of spatial fidelity is not an ancillary function; it is a core aim woven into every EGS activity, safeguarding the project against defects, rework, and functional failure.

The geodetic quality control process begins with the translation of abstract design coordinates into physical reality. Precise stakeout, guided by the project's high-accuracy control network, establishes the exact position, elevation, and alignment of every critical component – foundation piles, anchor bolts, structural grid lines, equipment pedestals, pipeline centerlines, and road alignments. This initial positioning is the first critical quality gate. However, EGS-driven QC extends far beyond initial marking. It involves continuous, proactive verification during construction. Geodetic personnel perform systematic checks at crucial junctures before work proceeds irreversibly. This includes verifying the position and elevation of reinforcing steel cages before concrete is poured, confirming the alignment and grade of pipelines before backfilling, checking the plumb and position of structural steel columns after erection but before final connections, and ensuring the correct placement of embedded parts or conduits. These interim checks are vital quality interventions, catching deviations early when corrections are feasible and cost-effective, preventing minor errors from cascading into major defects.

EGS provides objective, quantifiable validation of material placement and construction tolerances. In earthworks, periodic topographic surveys (increasingly using drones for efficiency) measure cut and fill volumes against design, ensuring earth is placed and compacted to specified grades and slopes, directly impacting foundation stability and drainage performance. For concrete pours, surveys verify formwork positioning and final slab elevations against tight tolerances. In pipeline construction, EGS confirms bend angles, fitting orientations, and the final as-laid position and depth, ensuring compliance with design stress profiles and burial requirements. For rotating machinery in power plants or refineries, the precise alignment of shafts, turbines, and pumps, verified by laser alignment tools integrated with geodetic methods, is paramount to prevent premature wear, vibration, and catastrophic failure. This empirical measurement provides irrefutable evidence of conformance or identifies non-conformances requiring remediation.

The culmination of construction-phase QC is the comprehensive as-built survey. Utilizing tools like terrestrial laser scanning, high-precision GNSS, and total stations, surveyors capture the exact spatial reality of the completed structure or system. This dense dataset is meticulously compared against the original design models and specifications. This final verification process identifies any discrepancies between "as-designed" and "as-constructed," documenting every element's true position, dimension, and elevation. The resulting authoritative as-built records are not merely archival; they are the definitive quality assurance documentation, essential for client acceptance, regulatory sign-off, and forming the accurate baseline for all future operations, maintenance, and modifications. They represent the geodetic certification of the built asset's spatial quality.

Furthermore, EGS sustains quality control throughout the operational lifespan via deformation monitoring. By continuously or periodically measuring structural movements and ground settlement with high precision, EGS provides early warning of developing issues that could compromise structural integrity or equipment function – such as excessive foundation settlement under a compressor, tilt in a cooling tower, or subsidence affecting pipeline support. Detecting these movements early allows for preventative maintenance or reinforcement, ensuring the asset continues to perform safely and efficiently to its design standards. Thus, geodetic QC is not a one-time event at project completion; it is an ongoing commitment to preserving the constructed quality and operational integrity of vital infrastructure over decades, ensuring it delivers reliable performance as intended by its designers and expected by its operators and the communities it serves.

16. Translate the text. (1800 printed characters; time – 45 min.)

Engineering Geodetic Support: The Engine of Infrastructure Efficiency

While precision and safety are fundamental pillars of Engineering Geodetic Support (EGS), its role as a critical driver of project and operational efficiency is equally profound and indispensable. Far from being a mere cost center or procedural hurdle, strategic EGS implementation actively

streamlines workflows, optimizes resource allocation, minimizes costly errors and delays, and maximizes the long-term value of infrastructure investments across the entire asset lifecycle. It transforms geospatial intelligence into tangible economic and temporal savings, proving that meticulous measurement is inherently efficient.

The efficiency gains begin decisively in the planning and design phase. High-precision topographic surveys and accurate existing condition models (captured via LiDAR, drones, or GNSS) provide designers with a reliable digital twin of the site. This eliminates costly assumptions, reduces the need for repeated site visits, enables precise volumetric calculations for earthworks balancing, and facilitates optimal site layout planning – minimizing earth movement, avoiding clashes with hidden utilities or terrain constraints, and optimizing access routes. Accurate spatial data integrated into Building Information Modeling (BIM) allows for sophisticated virtual construction and clash detection long before ground is broken, resolving spatial conflicts between architectural, structural, and MEP (Mechanical, Electrical, Plumbing) systems in the digital realm. This pre-emptive resolution prevents expensive rework, material waste, and schedule disruptions during physical construction, fundamentally compressing the design iteration cycle.

During the construction phase, EGS acts as the guarantor of execution efficiency. Precise and rapid stakeout using robotic total stations or GNSS-RTK ensures construction crews work correctly the first time. Equipment operators guided by machine control systems, fed directly by geodetic data and design models, achieve design grades and alignments with minimal passes, reducing fuel consumption, labor hours, and equipment wear. Continuous geodetic supervision and interim verification checks catch deviations early, when corrections are minor and inexpensive, preventing small errors from snowballing into major rework, demolition, or delays that ripple through the critical path. Accurate as-built surveys conducted progressively, often utilizing efficient drone photogrammetry for large areas, provide real-time progress tracking against the schedule and enable precise payment certification based on actual quantities installed, improving cash flow and reducing disputes. Furthermore, EGS enables just-in-time delivery of prefabricated components by ensuring their precise fit within the evolving structure, minimizing on-site storage and handling.

The efficiency imperative extends powerfully into long-term operations and maintenance. Comprehensive, accurate as-built documentation and BIM models, delivered as part of EGS, become the essential spatial reference for facility managers. This allows for rapid location of buried utilities, precise planning of maintenance activities, and efficient execution of repairs or modifications – drastically reducing search times, downtime, and the risk of accidental damage during interventions. Systematic deformation and subsidence monitoring provide early warning of developing issues. Addressing minor foundation settlement or pipeline stress points proactively, guided by precise geodetic data, is exponentially more efficient and less disruptive than emergency repairs following a catastrophic failure. Predictive maintenance informed by monitoring data optimizes resource allocation, scheduling interventions only when necessary and preventing unplanned outages that carry massive operational and financial penalties. For expansions or retrofits, existing accurate geospatial data allows for seamless integration planning, minimizing operational disruption and construction duration within live facilities.

Ultimately, EGS drives efficiency by transforming uncertainty into certainty and waste into value. It replaces guesswork and corrective actions with proactive, data-driven execution. The upfront investment in high-quality geodetic services yields substantial returns: reduced construction duration, lower material and labor costs, minimized rework, optimized resource utilization, extended asset lifespan through preventative care, and maximized operational uptime. In an industry where time is money and errors are magnified by scale, EGS is not an overhead; it is the intelligent geospatial framework that ensures projects are built right, on time, within budget, and operate reliably at peak performance for decades, delivering sustained efficiency from blueprint to decommissioning.

17. Translate the text. (1800 printed characters; time – 45 min.)

Engineering Geodetic Support (EGS) and Building Information Modeling (BIM): The Synergistic Foundation for Precision Construction and Lifecycle Management

Engineering Geodetic Support (EGS) is the specialized discipline applying precise geospatial

measurement, positioning, and monitoring techniques throughout the entire lifecycle of engineered structures and infrastructure. Its core functions encompass establishing control networks, topographic surveying, construction stakeout, as-built verification, deformation monitoring, and subsidence tracking. EGS ensures spatial accuracy, quality control, safety, and compliance, serving as the empirical link between design intent and physical reality.

Building Information Modeling (BIM) is a collaborative process centered on creating and managing intelligent, data-rich 3D digital representations of a facility's physical and functional characteristics. Beyond mere geometry, BIM models consist of parametric objects (walls, pipes, equipment) embedded with attributes (dimensions, materials, performance data, maintenance schedules). It functions as a shared knowledge resource from initial planning and design through construction, operation, maintenance, and eventual decommissioning, enabling informed decision-making, clash detection, quantity take-offs, and performance simulation.

EGS-BIM Integration: Creating a Continuous Digital Thread of Spatial Fidelity

The integration of EGS and BIM represents a transformative convergence, establishing a continuous, accurate, and intelligent digital thread that fundamentally enhances project delivery and asset management. This synergy is not merely data exchange; it is a bidirectional flow where precise geospatial reality informs and validates the digital model, and the intelligent model guides precise field operations.

1. Feeding the Model: EGS as the Spatial Anchor for BIM

Definitive Existing Conditions: High-precision EGS surveys (using GNSS, terrestrial LiDAR, UAV photogrammetry/LiDAR) capture the exact pre-construction state of the site and any existing structures. This accurate point cloud and topographic data forms the essential foundation upon which the new design BIM model is georeferenced and developed, eliminating guesswork and ensuring the design fits the real-world context.

Control Network Integration: The project's high-accuracy geodetic control points and datum are embedded within the BIM environment. This provides the absolute spatial reference frame for all model elements, ensuring design coordinates align seamlessly with the real-world coordinate system used for construction.

2. Guiding Construction: BIM Directing Precision EGS Execution

Model-Driven Stakeout: Robotic Total Stations (RTS) and GNSS receivers are directly guided by the BIM model's coordinates and geometry. Surveyors stake out foundations, structural elements, equipment locations, and piping routes precisely as defined in the intelligent 3D model, drastically reducing manual coordinate calculation errors and ensuring components fit as designed.

Automated Machine Control: Earthwork and paving equipment equipped with GPS/GNSS and guidance systems utilize surface models derived directly from the BIM design. This allows machines to achieve design grades and alignments automatically, guided by the digital model, optimizing efficiency and accuracy.

3. Verifying Reality: EGS Validating the As-Built Model

As-Built Verification via Scanning: During and after construction, terrestrial or mobile LiDAR scanners capture dense point clouds of the built asset. Specialized software compares this "as-constructed" point cloud directly against the "as-designed" BIM model, automatically identifying deviations, verifying tolerances, and quantifying construction accuracy.

Updating the Digital Twin: The results of as-built surveys are used to update the BIM model, transforming it from a design model into a verified Asset Information Model (AIM) or Digital Twin. This updated model reflects the true spatial and geometric state of the constructed facility, becoming the authoritative record for operations.

4. Empowering Operations and Maintenance: The Intelligent, Spatially Accurate Digital Twin

Spatially Intelligent Asset Management: The verified BIM model, enriched with precise EGS data, serves as the central hub for Facility Management (FM). Operators can visually locate assets (e.g., a specific valve on a pipeline), access linked maintenance records/manuals, and plan work within the accurate spatial context, reducing search time and downtime.

Integration of Monitoring Data: Continuous deformation or subsidence monitoring data (from automated total stations, GNSS, or InSAR) is fed into the BIM/Digital Twin environment. This allows visualization of structural movement trends over time directly within the spatial model of the asset, providing critical context for assessing risks, planning interventions, and predictive

maintenance.

Efficient Retrofits and Modifications: For expansions or upgrades within complex operational facilities (e.g., refineries, power plants), the spatially accurate AIM is indispensable. Engineers can virtually design and clash-check new components within the congested existing environment before physical work begins, ensuring fit and minimizing disruption. EGS then precisely stakes out the new elements based on this coordinated model.

5. Data Integration and Workflow: The Enabling Foundation

This seamless integration relies on standardized data formats (e.g., IFC - Industry Foundation Classes), robust data management platforms, and collaborative workflows defined by standards like ISO 19650. Cloud-based Common Data Environments (CDEs) facilitate the secure sharing and updating of both the BIM model and associated geospatial survey/monitoring data among all stakeholders.

A Paradigm Shift

The integration of EGS and BIM transcends traditional silos. It creates a powerful, closed-loop system: precise geospatial data builds and validates an intelligent digital model; the intelligent model guides precise field operations and informs long-term management; and ongoing monitoring feeds back into the model, ensuring it remains a true reflection of the physical asset. This synergy delivers unparalleled accuracy, reduces risk and rework, optimizes efficiency throughout the lifecycle, and establishes a reliable, spatially intelligent foundation for managing critical infrastructure assets over decades. EGS provides the spatial rigor; BIM provides the intelligent framework; together, they form the backbone of modern, data-driven engineering and construction.

18. Translate the text. (1800 printed characters; time – 45 min.)

Building Information Modeling (BIM) and Digital Twins: Complementary Pillars of the Modern Asset Lifecycle

Building Information Modeling (BIM) is a process centered on creating and managing an intelligent digital representation of a physical asset during its design and construction phases. A BIM model is a data-rich, object-oriented 3D virtual prototype where elements (walls, pipes, pumps, structural members) are not just graphical shapes but intelligent objects possessing defined attributes ("parameters") – dimensions, materials, performance specifications, cost data, manufacturer details, and maintenance requirements. BIM facilitates collaboration, enables clash detection before construction, generates accurate quantity take-offs, supports construction sequencing (4D), cost estimation (5D), and sustainability analysis (6D). Its primary focus is on the planning, design, and construction of the asset, serving as a shared single source of truth for the project team. The deliverable is a highly detailed "as-designed" or verified "as-built" model, representing the asset's intended or constructed state at a specific point in time (typically handover).

A Digital Twin, in contrast, is a dynamic, living virtual replica of a physical asset or system throughout its entire operational lifespan. It goes far beyond the static geometry and embedded data of a BIM model. A true Digital Twin is characterized by its bidirectional data flow:

1. Real-Time Data Integration: It continuously ingests live data streams from sensors embedded within the physical asset (IoT - Internet of Things). This includes operational data (temperatures, pressures, flow rates, energy consumption, vibration levels), environmental conditions, and crucially, real-time spatial performance data from integrated geodetic monitoring systems (automated total stations, GNSS, tiltmeters, strain gauges) tracking deformation, settlement, or movement.
2. Analytics, Simulation & AI: The twin utilizes this real-time and historical data with advanced analytics, machine learning (ML), and physics-based simulation models to understand current performance, diagnose issues, predict future behavior (e.g., remaining useful life of equipment, potential failure points based on stress/strain patterns), and simulate "what-if" scenarios.
3. Feedback & Optimization: Insights derived from the twin can be fed back to optimize the physical asset's operation in real-time (e.g., adjusting pump settings for efficiency) or to inform maintenance schedules, capital planning, and future modifications.

Synergy: BIM as the Foundational Genesis of the Digital Twin

The verified "as-built" BIM model (often termed an Asset Information Model - AIM) frequently serves as the essential spatial and geometric foundation for creating the initial Digital Twin,

particularly for complex infrastructure like power plants or refineries. It provides the accurate 3D context and the initial "digital thread" of component information. The twin then builds upon and enriches this static model with the continuous flow of operational and performance data.

Key Differences: Purpose, Dynamism, and Scope

Core Purpose:

BIM: Optimize the design and construction process, ensuring accuracy, reducing errors/clashes, improving collaboration, and delivering a high-quality asset. It answers "How do we design and build it correctly?"

Digital Twin: Optimize the operational performance, maintenance, and management of the existing asset throughout its life. It answers "How is it performing now? How can we operate/maintain/improve it best? What will happen next?"

Nature & Data Flow:

BIM: Primarily static or periodically updated (e.g., design revisions, as-built updates). Data flow is largely unidirectional into the model during creation/construction. Its value peaks at project handover.

Digital Twin: Inherently dynamic and continuously evolving. Features bidirectional data flow: real-time sensor data into the twin, and insights/commands potentially back to the physical asset or operators. Its value grows continuously during operations.

Temporal Focus:

BIM: Focuses on the asset from conception through construction completion/handover.

Digital Twin: Focuses on the asset from commissioning through its entire operational life to decommissioning.

Data Scope:

BIM: Contains design, construction, and component metadata (geometric, specifications, procurement, installation).

Digital Twin: Contains BIM data plus vast streams of real-time operational data (IoT sensors), control system data, maintenance history, performance logs, financial data (O&M costs), and sophisticated analytical models.

Primary Users:

BIM: Architects, Engineers, Contractors, Project Managers (design/construction teams).

Digital Twin: Facility Managers, Operations Teams, Maintenance Engineers, Reliability Engineers, Asset Managers, Executive Decision-Makers (operators/owners).

Why the Distinction Matters

Confusing a static BIM model with a dynamic Digital Twin leads to missed opportunities. A BIM model is a crucial step, but a true Digital Twin represents a paradigm shift in asset management. It transforms reactive maintenance into predictive strategies, optimizes energy consumption in real-time based on actual load and weather, simulates the impact of proposed modifications before implementation, provides immersive training environments using the virtual replica, and fundamentally enhances safety by providing unprecedented insight into the asset's real-time condition and future risks. While BIM ensures the asset is built right, the Digital Twin ensures it operates right, lasts longer, and delivers maximum value over its entire lifecycle. Together, they form a powerful continuum: BIM provides the accurate digital birth certificate, and the Digital Twin becomes the living, breathing digital counterpart guiding the asset's operational life.

19. Translate the text. (1800 printed characters; time – 45 min.)

Advanced Geospatial Data Acquisition: Core Methods for Engineering Geodetic Support

Engineering Geodetic Support (EGS) relies on sophisticated technologies to capture the precise spatial reality of sites, structures, and subsea environments. Three methods stand out for their transformative impact: Terrestrial Laser Scanning (LiDAR), Aerial/UAV-based Photogrammetry & LiDAR, and Hydrographic Surveying. Each offers unique capabilities essential for different phases and challenges within the infrastructure lifecycle.

1. Terrestrial Laser Scanning (TLS / LiDAR): Capturing the Intricate Built World

Terrestrial Laser Scanning (TLS), often referred to as LiDAR (Light Detection and Ranging), involves stationary ground-based instruments that rapidly emit millions of laser pulses. These pulses measure distances to surrounding surfaces with millimeter accuracy, generating a dense, precise 3D "point cloud" – a massive dataset where each point has known X, Y, Z coordinates and often

intensity/color values. TLS excels in capturing complex geometries, congested environments, and intricate details of existing structures (refineries, bridges, building interiors, historical monuments) or newly constructed elements. Its key strengths lie in its ultra-high spatial resolution and accuracy at close range, ability to operate without external lighting, and capacity to capture hard-to-reach areas safely. Primary EGS applications include generating millimeter-accurate as-built documentation for verification against design models (BIM), conducting detailed deformation analysis by comparing point clouds captured over time, performing clash detection during retrofits, calculating stockpile volumes, and creating detailed 3D models for forensic investigation or planning. The resulting point cloud is the foundational raw data, processed into deliverables like surface models, 2D drawings, or directly integrated into CAD/BIM platforms.

2. Aerial/UAV Photogrammetry & LiDAR: The Bird's-Eye Perspective Revolution

This category leverages airborne platforms – traditionally manned aircraft but increasingly Unmanned Aerial Vehicles (UAVs or drones) – equipped with specialized sensors. Photogrammetry uses high-resolution cameras capturing hundreds of overlapping aerial images during systematic flight patterns. Sophisticated software (using Structure-from-Motion - SfM algorithms) processes these images, matching features to calculate precise 3D positions, generating outputs like orthophotos (geometrically corrected aerial maps), dense 3D point clouds, Digital Surface Models (DSMs) showing the top of visible features (trees, buildings), and filtered Digital Terrain Models (DTMs) representing the bare earth surface. UAV LiDAR mounts a lightweight laser scanner on the drone, directly measuring distances to the ground and objects, providing its own 3D point cloud. The critical advantage of UAV LiDAR is its ability to penetrate vegetation canopy to capture ground points below, unlike photogrammetry which only sees the top surface. UAV-based methods offer unparalleled speed, coverage, and safety for accessing large, remote, or hazardous areas (quarries, steep slopes, post-disaster sites, pipeline corridors). Core EGS uses include large-scale topographic mapping for design, construction progress monitoring, earthwork volume calculations, corridor surveys for linear infrastructure (roads, power lines, pipelines), inspection of roofs, facades, or hard-to-reach structures, and environmental monitoring. UAVs deliver efficiency and cost-effectiveness, particularly for repetitive monitoring tasks.

3. Hydrographic Surveying: Mapping the Subsurface Realm

Hydrographic Surveying is the specialized branch of geomatics focused on measuring and describing the physical features of underwater environments – the seafloor, riverbeds, lake bottoms, and submerged structures (pipelines, cables, foundations, wrecks). The primary tool is the echosounder. Multibeam Echosounders (MBES) emit a wide fan of sound beams perpendicular to the vessel's track, measuring water depth across a swath and creating high-resolution, full-coverage bathymetric maps. Singlebeam Echosounders (SBES) measure depth directly beneath the vessel, suitable for less complex surveys. Achieving accurate underwater positioning requires tightly integrated systems: High-Precision GNSS (e.g., RTK, PPK) provides the vessel's location, while an Inertial Measurement Unit (IMU) measures its precise attitude (pitch, roll, heading, heave). A sound velocity profiler constantly measures water column sound speed variations, critical for correcting depth measurements. Hydrographic deliverables include bathymetric charts, Digital Terrain Models (DTMs) of the seabed, contour maps, and identification of submerged features or obstructions. This is vital EGS for offshore oil & gas platform installation, subsea pipeline/cable route surveying (pre-lay, as-laid, post-lay), dredging operations (pre-dredge surveys, volume control, verification), port and harbor maintenance, dam reservoir surveys, and assessing scour around bridge piers or offshore structures. It ensures safe navigation, efficient marine construction, and the integrity of underwater infrastructure.

Complementary Tools for Comprehensive Understanding

These three methods form a powerful geospatial toolkit. TLS provides unmatched detail for complex, confined, or critical structural elements. UAV Photogrammetry and LiDAR offer rapid, extensive coverage of terrestrial surfaces, with LiDAR excelling in vegetated terrain. Hydrographic surveying unlocks the essential third dimension beneath the waterline. Their intelligent selection and integration, guided by project-specific requirements for accuracy, coverage, resolution, and environment, enable Engineering Geodetic Support to deliver the precise spatial intelligence fundamental to building, monitoring, and maintaining safe, efficient, and resilient infrastructure across all terrains.

20. Translate the text. (1800 printed characters; time – 45 min.)

Why Engineering Geodetic Support is Indispensable in Oil, Gas & Energy

The oil, gas, and energy sectors represent the backbone of modern industrial society, operating vast, complex, and inherently high-risk infrastructure. Within this high-stakes environment, Engineering Geodetic Support (EGS) transcends being a technical service; it is a fundamental pillar of safety, efficiency, regulatory compliance, and long-term asset integrity. Its vital importance stems from the unique confluence of scale, precision demands, environmental challenges, catastrophic risk potential, and extended operational lifespans characterizing these industries.

Firstly, the sheer scale and complexity of projects demand unparalleled spatial control. Offshore platforms are intricate cities built in open ocean depths, requiring millimeter-precise positioning of thousands of tons of steel during installation and interconnection. Pipeline networks stretch for thousands of kilometers across diverse, often inaccessible terrain, demanding consistent alignment and depth control. Refineries and petrochemical plants are dense mazes of piping, structures, and critical equipment where spatial conflicts are not just costly but potentially disastrous. Power plants, whether thermal, nuclear, or hydro, house massive turbines, generators, and reactors requiring exacting alignment and foundation stability. EGS provides the high-precision geodetic control networks, meticulous stakeout, and rigorous as-built verification essential to construct and integrate these colossal, interdependent systems correctly the first time. Errors in positioning during construction, undetected due to inadequate surveying, can lead to misaligned flanges causing leaks, structural instability, or costly rework cascading into massive delays.

Secondly, the consequences of failure are catastrophic. A minor undetected misalignment in high-pressure gas piping, excessive foundation settlement under a critical compressor, undiagnosed subsidence along a pipeline route, or unforeseen deformation of a dam abutment can trigger explosions, toxic releases, fires, environmental devastation (oil spills, contamination), massive financial losses, and tragic loss of life. EGS acts as a primary safeguard against these risks. Continuous deformation monitoring systems using automated total stations, GNSS, and InSAR provide early warning of developing structural issues or ground movement. Precise subsidence monitoring in extraction zones (oil fields, mines) is critical for predicting and mitigating ground settlement impacts on pipelines, wellheads, and surface facilities. Hydrographic surveying ensures safe pipeline landfalls and platform placements, avoiding seabed hazards. The millimeter-level precision of EGS in construction and the vigilant eye of its monitoring systems are the first line of defense against low-probability, high-consequence events.

Thirdly, operations frequently occur in extremely harsh and remote environments. Offshore surveys face relentless waves, wind, and corrosive saltwater, demanding robust equipment and specialized techniques like GNSS-aided vessel positioning and dynamic referencing for platform surveys. Arctic projects contend with permafrost instability, requiring sophisticated monitoring to track ground thermal changes affecting foundations and pipelines. Desert pipelines cross shifting sands, while transmission lines traverse rugged mountains and dense forests. EGS technologies adapted to these conditions – ruggedized GNSS, UAVs for corridor mapping in difficult terrain, satellite-based InSAR for wide-area monitoring in remote locations – provide the essential spatial intelligence where conventional methods falter. The ability to deliver accurate data under these duresses is non-negotiable for safe and efficient operations.

Fourthly, the extended operational lifespans of assets (often 30-50+ years) necessitate continuous vigilance. Structures and foundations experience long-term stresses, ground conditions evolve (especially in extraction zones), and materials fatigue. EGS is not a one-time construction activity; its long-term deformation and subsidence monitoring programs are crucial for ongoing asset integrity management. Detecting subtle movements early allows for predictive maintenance and proactive interventions, preventing minor issues from escalating into catastrophic failures and extending the safe operational life of multi-billion dollar investments.

Finally, the sectors operate under intense regulatory scrutiny. Strict national and international regulations govern every aspect, from construction tolerances and pipeline burial depths to mandatory structural health monitoring programs for dams, nuclear facilities, and offshore platforms. Comprehensive, auditable EGS documentation – accurate as-built records, deformation monitoring

reports, subsidence analysis – is essential for demonstrating compliance, securing operating permits, managing liability, and providing evidence of responsible operational practices. EGS provides the objective, quantifiable geospatial data required to meet these stringent regulatory demands.

In essence, EGS is vital in oil, gas, and energy because it directly addresses the core challenges: building immensely complex systems with zero margin for spatial error, operating them safely within unforgiving environments over decades, and relentlessly guarding against failures with catastrophic consequences. It transforms geospatial precision into the bedrock of safety, efficiency, regulatory compliance, and the sustainable longevity of the infrastructure powering our world.

21. Look through the text and say what it is about. (preparation time - 15 min.).

Geometric Leveling: An Overview

Geometric leveling is a fundamental surveying technique used to determine the relative heights or elevations of different points on the Earth's surface. It is essential in various engineering projects, such as construction, road design, drainage planning, and mapping, where precise elevation data is crucial.

Principles of Geometric Leveling

At its core, geometric leveling is based on the principle of measuring vertical distances (differences in elevation) between points using an optical instrument called a level, along with a staff or rod. The basic idea is to establish a horizontal line of sight and measure the height difference between the instrument's line of sight and the points of interest.

Types of Geometric Leveling

1. Differential Leveling: Involves taking a series of readings from one point to another, measuring the difference in elevation between successive points.
2. Profile Leveling: Used to determine the elevation change along a specific line or route.
3. Fly Leveling: A rapid method for temporary or less precise measurements over a large area.

Instruments Used

- Dumpy Level: A simple, fixed-magnification instrument suitable for standard applications.
- Automatic (Self-Aligning) Level: Provides more accurate and easier readings.
- Digital Levels: Use electronic sensors for high-precision measurements.

Procedure of Geometric Leveling

1. Setup: The level is set up on a stable tripod over a benchmark or known elevation point.
2. Focusing: The instrument is leveled using foot screws until the bubble is centered.
3. Reading the Staff: The staff is placed on the point whose elevation is to be determined. The observer reads the staff through the telescope at the line of sight.
4. Recording: The reading (height of instrument plus staff reading) is recorded.
5. Moving to Next Point: The staff is moved to the next point, and the process repeats.
6. Backsight and Foresight:
   - Backsight (BS): The reading taken on a benchmark or known point to establish the instrument's height.
   - Foresight (FS): The reading on the new point.
7. Calculations: The difference between Backsight and Foresight readings gives the change in elevation.

Calculations

The elevation of a point is calculated as:

Elevation of point = Elevation of benchmark + Backsight – Foresight

or, when moving along a chain of points:

Elevation of subsequent point = Elevation of previous point + Backsight – Foresight

Accuracy and Error Correction

- Proper setup and leveling of the instrument are vital.
- Readings should be taken carefully to avoid parallax errors.
- Repeated measurements improve accuracy.
- Corrections may be applied for refraction and curvature over long distances.

Advantages of Geometric Leveling

- High precision in elevation measurements.
- Suitable for detailed topographical surveys.
- Relatively quick and straightforward with proper equipment.

Applications
- Construction site leveling.
- Highway and railway design.
- Drainage and flood control planning.
- Mapping and land development.

Geometric leveling is a vital surveying technique that provides accurate elevation data essential for engineering and construction projects. Mastery of its principles and procedures ensures reliable results, facilitating successful project planning and execution.

22. Look through the text and say what it is about. (preparation time - 15 min.).

Triangulation

Triangulation is a fundamental concept in various fields such as geography, navigation, surveying, and social sciences, serving as a method to determine an unknown position or to analyze relationships by using geometric principles. At its core, triangulation involves the use of triangles—simple geometric shapes with three sides and three angles—to measure distances, map locations, or understand complex structures. The principle relies on the fact that if the lengths of at least two sides of a triangle and one angle are known, or if two angles and a side are known, the remaining sides and angles can be accurately calculated through basic trigonometry.

Historically, triangulation revolutionized land surveying and cartography. Surveyors would establish a network of triangles across a region, often starting from a known baseline. By measuring the angles from specific points and knowing the baseline length, they could accurately compute the positions of unmarked locations or boundaries. This method allowed for the creation of detailed maps over large areas with high precision, which was essential for land division, construction projects, and navigation. The development of triangulation networks in the 18th and 19th centuries was instrumental in the creation of national coordinate systems and geographic databases, laying the groundwork for modern geographic information systems (GIS).

In contemporary applications, triangulation extends beyond physical measurements. In navigation systems such as GPS, triangulation is used to determine a receiver's location by calculating distances from multiple satellites, each providing a known position. By measuring the time it takes for signals to travel from satellites to the receiver, the system estimates distances and uses geometric principles to pinpoint the exact location. Similarly, in wireless communications, triangulation helps locate devices or signal sources by analyzing signal strengths and timings from multiple antennas. In social sciences and research, triangulation refers to the use of multiple methods or data sources to validate findings, thereby increasing the reliability and depth of analysis. This metaphorical use underscores the idea of combining different perspectives or data points to arrive at a more comprehensive understanding.

Overall, triangulation exemplifies how simple geometric concepts can be harnessed to solve complex real-world problems. Its versatility across disciplines highlights its importance as a foundational technique for measurement, navigation, mapping, and validation. As technology advances, the principles of triangulation continue to underpin innovations in positioning, sensing, and data validation, demonstrating that the humble triangle remains a powerful tool for understanding and navigating our world.

23. Look through the text and say what it is about. (preparation time - 15 min.).

Trilateration

Trilateration is a fundamental technique used in navigation and positioning systems to determine the exact location of an object or point in space by measuring distances from known reference points. This method relies on the principle that if the distances to at least three known points are known, the position of the unknown point can be precisely calculated. It is widely employed in various fields, including GPS technology, radio navigation, and surveying, to establish accurate positional information.

The process of trilateration involves drawing circles (or spheres in three dimensions) around each of the known reference points, with radii equal to the measured distances to the unknown point. The intersection point of these circles (or spheres) indicates the location of the target. In two-dimensional space, the intersection of three circles typically pinpoints a single location, provided the distance

measurements are accurate. In three-dimensional applications, three spheres are used, and their common intersection defines the position in space.

GPS systems exemplify trilateration in action. Satellites orbiting the Earth transmit signals that include their positions and the time the message was sent. A GPS receiver, located somewhere on Earth's surface, receives these signals and measures the time delay for each, which translates into the distance to each satellite. Using the known positions of the satellites and the measured distances, the receiver performs trilateration to compute its precise location, often expressed in latitude, longitude, and altitude. This process requires at least four satellites to account for clock errors and enhance accuracy.

Overall, trilateration is a powerful and reliable method for position determination, enabling modern navigation and location-based services that are integral to daily life, from smartphone mapping applications to autonomous vehicle navigation systems. Its reliance on geometric principles makes it both robust and precise, provided the distance measurements are accurate and the reference points are well-known.

24. Look through the text and say what it is about. (preparation time - 15 min.).

Geographic Information Systems

Geographic Information Systems (GIS) have become an integral part of modern society, transforming the way we analyze and interpret spatial data. At its core, GIS is a framework that allows users to capture, store, manipulate, analyze, manage, and present geographic information. By integrating various layers of data, GIS enables a comprehensive understanding of spatial relationships and patterns that are often invisible through traditional analysis methods.

The foundation of GIS lies in its ability to handle diverse data types, including vector data, which represents features such as roads, buildings, and boundaries, and raster data, which encompasses images like satellite photographs and aerial imagery. These layers can be overlaid and analyzed to reveal insights that support decision-making across numerous fields. For example, urban planners utilize GIS to optimize land use, minimize environmental impact, and plan infrastructure development. Environmental scientists employ GIS to monitor changes in ecosystems, track deforestation, and model climate change impacts. Emergency responders rely on GIS for disaster management, locating resources, and planning evacuation routes.

Advancements in technology have significantly expanded the capabilities of GIS. The proliferation of high-resolution satellite imagery, GPS technology, and the internet has facilitated real-time data collection and sharing. Cloud-based GIS platforms allow for collaborative analysis and accessibility from anywhere in the world, enhancing responsiveness and coordination among stakeholders. Moreover, the integration of GIS with other technologies, such as artificial intelligence and machine learning, opens new frontiers in predictive modeling and automated analysis, enabling more proactive and informed decision-making.

Despite its many benefits, GIS also faces challenges. Data quality and accuracy are paramount, as unreliable data can lead to misguided decisions. Privacy concerns arise when geospatial data involves sensitive information about individuals or communities. Additionally, the complexity of GIS software can present barriers for users lacking technical expertise, emphasizing the need for education and training. As the technology continues to evolve, addressing these issues will be crucial for maximizing the potential of GIS while safeguarding ethical considerations.

In conclusion, GIS is a powerful tool that bridges the gap between geography and technology, providing valuable insights across multiple domains. Its ability to visualize and analyze spatial data empowers organizations and governments to make informed decisions that enhance sustainability, safety, and efficiency. As data collection methods become more sophisticated and accessible, GIS will undoubtedly play an increasingly vital role in shaping a smarter, more connected world.

25. Look through the text and say what it is about. (preparation time - 15 min.).

Total Stations & Robotic Total Stations: Precision Workhorses of Geodetic Control

The Total Station (TS) is a fundamental electronic/optical surveying instrument essential for Engineering Geodetic Support (EGS). It integrates three core functions: an electronic theodolite for

measuring horizontal and vertical angles with high precision (typically to seconds of arc), an electronic distance meter (EDM) using infrared or laser light to measure slope distances to a reflective prism (with millimeter to centimeter accuracy), and an on-board microprocessor with data storage. Operators manually sight the instrument's telescope crosshairs onto a prism held by a rodperson at the target point. The TS measures the angles and distance, then calculates the 3D coordinates (Northing, Easting, Elevation) of the target point relative to the instrument's position and a known reference point (back sight). Data is recorded manually in field books or, more commonly now, electronically in onboard memory or external data collectors. Key purposes include establishing control networks, topographic detail surveys, construction stakeout, as-built verification, and precise monitoring where automation isn't critical.

The Robotic Total Station (RTS) represents a significant technological evolution, automating the most time-consuming manual task: target tracking. An RTS incorporates a motorized drive system and automatic target recognition (ATR) technology. The operator controls the instrument remotely via a rugged field controller (tablet or handheld unit). Once the RTS is set up over a known point and oriented, the operator simply commands it to locate a specific prism (either by searching or entering its approximate location). The RTS automatically finds, locks onto, and continuously tracks the prism as the rodperson moves around the site. This enables true one-person operation: the single surveyor carries the prism pole and controller, directing the RTS from the target location. The RTS continuously measures angles and distances as the prism moves, instantly calculating coordinates and sending them to the controller for verification, recording, or stakeout guidance. This automation drastically increases survey speed and efficiency, particularly for complex layouts or large-scale topo surveys.

Operations and Core Purposes:

Both TS and RTS perform the same fundamental measurements: angles and distances to prisms. Their core operational purposes within EGS are identical:

1. Precise Stakeout: Marking design points (foundations, columns, equipment pads, pipelines, roads) accurately on the ground using coordinates from plans/BIM models.
2. Control Network Establishment & Densification: Creating high-accuracy reference points across a site.
3. Topographic & As-Built Surveys: Capturing the precise location and elevation of existing features or newly constructed elements.
4. Deformation Monitoring: Measuring displacements of prisms attached to structures over time (manually with TS, often automated/continuous with RTS).
5. Geometric Control: Verifying alignment, elevation, verticality, and dimensions during construction.

The RTS Advantage:

Dramatically Increased Productivity: One-person operation eliminates constant communication and walking back to the instrument. Automatic tracking allows rapid data collection or layout of numerous points.

Reduced Human Error: Minimizes pointing/sighting errors and miscommunication.

Enhanced Safety: The operator works away from the instrument, beneficial near traffic, moving machinery, or on unstable ground.

Enables Complex Layouts: Efficiently handles intricate patterns or numerous points.

Foundation for Automation: RTS is the core sensor in Automated Deformation Monitoring Systems (ADMS), providing continuous, unattended measurements.

While the standard TS remains valuable for specific tasks or budget constraints, the Robotic Total Station has become the dominant instrument for most construction and engineering surveying due to its unparalleled efficiency, accuracy, and ability to streamline workflows, making it an indispensable tool for modern EGS.

26. Look through the text and say what it is about. (preparation time - 15 min.).

Geodetic and topographic surveys

Geodetic and topographic surveys are fundamental techniques used in the field of surveying to gather essential data about the Earth's surface, each serving distinct purposes and employing different methodologies. Geodetic surveys are comprehensive measurements that account for the curvature of the Earth, aiming to establish precise positions over large areas with high accuracy. They are crucial

for creating coordinate systems, mapping large regions, and supporting activities such as engineering projects, navigation, and scientific research. These surveys typically involve the use of sophisticated instruments like GPS, theodolites, and electronic distance measurement devices to determine geographical coordinates with minimal errors, ensuring that spatial data remains consistent over vast distances.

In contrast, topographic surveys focus on capturing the detailed features of a specific area, including natural elements like hills, rivers, and vegetation, as well as man-made structures such as buildings, roads, and fences. The primary goal is to produce detailed maps or plans that depict the surface features and terrain elevations, which are essential for urban planning, construction, landscaping, and environmental management. Topographic surveys are generally conducted over smaller areas and employ techniques such as total stations, level instruments, and photogrammetry to gather detailed data about the surface features.

The key differences between the two surveys lie in their scope, accuracy, and purpose. Geodetic surveys are extensive and aim for absolute positioning accuracy across large regions, taking into account the Earth's curvature. Topographic surveys are more localized, emphasizing detailed surface features without necessarily accounting for the Earth's curvature, although they provide critical information for design and construction. Their applications are equally diverse; geodetic surveys underpin the creation of coordinate systems used in navigation, cartography, and large-scale infrastructure projects, while topographic surveys support site planning, civil engineering, and environmental management. Both types of surveys are vital in ensuring the precision and reliability of spatial data, ultimately facilitating informed decision-making across various disciplines.

27. Look through the text and say what it is about. (preparation time - 15 min.).

Measuring polygons

Measuring polygons accurately at construction sites is a crucial task that ensures the precise layout and structural integrity of any project. To begin, it’s essential to have the right tools, such as a tape measure, a theodolite or total station, a measuring wheel, and a GPS device if available. The process starts with establishing a clear baseline or reference points using stakes and markers. These points serve as the foundation for calculating the positions of the polygon's vertices.

Next, establish the first point by marking it clearly and recording its coordinates or distances from known reference points. Using a theodolite or total station, measure the angles between this initial point and subsequent points around the polygon. These angles, combined with distance measurements obtained via tape or electronic distance measurement (EDM) devices, allow you to determine the precise locations of each vertex. For irregular polygons, it’s important to measure all sides and interior angles carefully, ensuring that the sum of angles aligns with geometric expectations.

To improve accuracy, double-check measurements by repeating the process from different reference points or using redundant measurements. Once all vertices are located, connect the points accurately on the ground, verifying that the polygon’s shape conforms to the design plans. Document all measurements meticulously, noting any deviations or anomalies. Properly marking and recording these points ensures that the construction aligns precisely with the intended design, reducing errors and rework. With careful measurement and recording, you can reliably define complex polygonal shapes at construction sites, ensuring the project’s success and structural integrity.

28. Look through the text and say what it is about. (preparation time - 15 min.).

The history of geodesy till the 19th century

The history of geodesy, the science concerned with measuring and understanding the Earth's shape, size, and gravitational field, is a fascinating journey that spans thousands of years. Its evolution reflects humanity's enduring quest to comprehend our planet, driven by practical needs such as land division, navigation, and scientific curiosity.

Ancient civilizations laid the foundational principles of geodesy. The earliest records come from the Egyptians around 3000 BCE, who employed simple surveying techniques to delineate land boundaries after the annual flooding of the Nile River. They recognized the importance of precise measurements for agriculture and taxation. The Babylonians and Assyrians also engaged in land measurement, utilizing rudimentary tools like ropes and plumb lines. In ancient Greece,

mathematicians such as Eratosthenes of Cyrene (circa 276–194 BCE) made groundbreaking contributions. Eratosthenes is famously credited with estimating the Earth's circumference with remarkable accuracy by comparing the angle of the Sun's rays at two different locations, Alexandria and Syene (modern-day Aswan). His method involved measuring the shadow cast by a stick at noon and applying basic geometry, establishing one of the earliest scientific methods for understanding Earth's size.

During the Roman Empire and into the Middle Ages, geodesy continued to develop through the efforts of various surveyors and scholars. The Romans advanced land surveying techniques, constructing extensive networks of roads and aqueducts with precise measurements. However, systematic scientific approaches to Earth's shape remained limited until the Renaissance.

The Renaissance era marked a renewed interest in scientific inquiry and exploration. The 16th and 17th centuries saw significant progress with the advent of more sophisticated instruments. Notably, the invention of the telescope and improvements in geometric methods allowed for better measurements. In 1672, Isaac Newton hypothesized that the Earth was not a perfect sphere but an oblate spheroid—flattened at the poles—based on his studies of gravity and planetary motion. This insight prompted further investigations into Earth's shape.

The 18th century was a pivotal period for geodesy, driven largely by the need for accurate mapping for navigation, military, and scientific purposes. The French Academy of Sciences organized large-scale geodetic surveys, such as the Cassini mission, which aimed to measure the meridian arc from Dunkerque to Barcelona. These efforts resulted in more precise models of Earth's shape, leading to the adoption of the reference ellipsoid and the development of geodetic datums. The advent of triangulation methods allowed for the measurement of vast areas with improved accuracy.

29. Look through the text and say what it is about. (preparation time - 15 min.).

The history of geodesy

The 19th century heralded technological advancements with the development of more accurate theodolites, baseline measurement techniques, and the establishment of international standards. The creation of national geodetic networks and the development of gravity measurements further refined our understanding of Earth's shape and gravitational field. The concept of geodetic datums became standardized, providing essential frameworks for mapping and navigation.

The 20th century witnessed a transformative leap with the introduction of electronic distance measurement (EDM) instruments, which vastly increased measurement precision. A major milestone was the advent of satellite geodesy in the latter half of the century. The launch of artificial satellites, beginning with Sputnik in 1957, revolutionized geodesy by enabling global measurements of Earth's shape and gravity field. Satellite tracking techniques, such as Doppler shifts and later laser ranging, allowed scientists to determine Earth's parameters with unprecedented accuracy.

The development of global navigation satellite systems (GNSS), including GPS (Global Positioning System), GLONASS, Galileo, and BeiDou, has further advanced the field. These systems provide real-time positioning data with centimeter-level accuracy, transforming navigation, surveying, and Earth sciences. Satellite altimetry, gravity field measurements, and Earth observation missions have enriched our understanding of Earth's dynamic processes, including plate tectonics, sea level rise, and climate change.

Today, geodesy continues to evolve with technological innovations like interferometric synthetic aperture radar (InSAR), gravimetric satellites, and terrestrial laser scanning. The field integrates data from multiple sources to create highly detailed models of Earth's surface and interior, supporting scientific research and practical applications worldwide.

In summary, the history of geodesy reflects a continuous journey from primitive land measurements to sophisticated satellite-based systems. Each era built upon previous discoveries, driven by the need for more precise, comprehensive knowledge of our planet. As technology advances, geodesy remains a vital discipline, expanding our understanding of Earth's complex systems and helping humanity navigate and manage our home planet more effectively.

30. Look through the text and say what it is about. (preparation time - 15 min.).

Units of measurement

Units of measurement are fundamental to understanding and quantifying the world around us, enabling consistent communication and comparison of physical quantities such as length, mass, time, and angles. Among the various systems used worldwide, the International System of Units (SI) is the most widely adopted, providing a standardized framework for scientific, industrial, and everyday measurements. Developed in France and officially adopted in 1960, the SI system is based on the metric system, with seven base units including the meter for length, the kilogram for mass, and the second for time. These units are interconnected through prefixes that denote multiples or fractions, facilitating precise and scalable measurements across diverse fields.

Angles are a key concept in geometry and physics, representing the measure of rotation between two intersecting lines or planes. The most common unit for measuring angles in the SI system is the radian, which is defined as the angle subtended at the center of a circle by an arc equal in length to the radius of the circle. One radian is approximately 57.2958 degrees. Degrees, another unit of measurement for angles, are more familiar in everyday contexts and are subdivided into 60 minutes, each consisting of 60 seconds. This sexagesimal system of degrees originated in ancient civilizations and remains prevalent in navigation, engineering, and astronomy.

Lines are fundamental in geometry, characterized as infinitely extending in both directions. They can be classified as parallel, intersecting, or skew, depending on their spatial relationships. When two lines intersect, they form angles at the point of intersection, which can be classified as either complementary (summing to 90 degrees) or supplementary (summing to 180 degrees). Understanding lines and angles is essential for the study of shapes, construction, and design.

The SI system primarily uses the meter for length measurement, but in everyday contexts, especially in the United States and historically in England, customary units are often employed. The imperial system, used predominantly in the United Kingdom and the United States, includes units like inches, feet, yards, and miles for length. One foot equals 12 inches, one yard equals 3 feet, and one mile equals 1,760 yards or approximately 1.609 kilometers. These units are customary rather than metric, and their use varies depending on the context—engineering, navigation, or casual conversation.

In the United States, the imperial system remains the standard for most everyday measurements, including construction, real estate, and personal height and weight. Conversely, the UK has largely transitioned to the metric system for most scientific, commercial, and governmental purposes. However, some imperial units, such as miles for road distances and pints for beer, are still in common use in Britain. The historical roots of these measurement systems date back centuries, with the imperial units originating from standards established in the British Empire.

The differences between the SI system and the imperial or customary units can sometimes lead to confusion, especially in international contexts. For example, a mile in the imperial system is longer than a kilometer, and an inch is smaller than a centimeter. To facilitate international trade, science, and technology, SI units are preferred because of their consistency and universal acceptance. Nonetheless, understanding both measurement systems is essential for effective communication across different countries and fields.

Angles and lines are also measured and analyzed differently in various systems. In the SI system, angles are measured in radians for scientific purposes, especially in calculus and physics, because radians provide a natural measure for describing rotational motion and periodic functions. For practical applications like navigation and engineering, degrees are more common, with the full circle divided into 360 degrees, a convention that dates back to ancient Babylonian astronomy. This division allows for straightforward subdivision of angles, making it easier to measure and communicate directions and orientations.

Lines play a crucial role in geometry and trigonometry, where their properties help define shapes, solve problems, and describe spatial relationships. Parallel lines remain equidistant and never meet, while intersecting lines do so at a single point, forming angles that can be analyzed to understand geometric configurations. The study of lines and angles underpins many fields, including architecture, engineering, and computer graphics, where precise measurements are vital.

In summary, units of measurement, angles, and lines form the backbone of quantitative understanding in science, engineering, and daily life. The SI system provides a universal standard that promotes consistency and clarity, especially in scientific contexts, while the imperial system persists in certain regions like the United States and the UK for historical and practical reasons. Both

systems involve the measurement of length, angles, and spatial relationships, but their differences highlight the importance of context and convention in measurement practices. As global interaction increases, familiarity with both systems and their underlying principles becomes increasingly valuable, enabling better communication, collaboration, and innovation across cultures and disciplines.

31. Look through the text and say what it is about. (preparation time - 15 min.).

Geodetic networks

Geodetic networks are fundamental frameworks used in surveying, mapping, and various geospatial applications to establish precise positions of points on the Earth's surface. These networks are classified based on their configuration, purpose, and the accuracy requirements they fulfill. Understanding the different types and classes of geodetic networks is essential for selecting the appropriate approach for a given project, whether it involves large-scale mapping, engineering design, or scientific research.

Primarily, geodetic networks can be categorized into three main types: triangulation networks, trilateration networks, and traversing networks. Triangulation networks are among the oldest and most widespread; they are constructed by establishing a series of interconnected triangles, where the angles of each triangle are measured with high precision. The known baseline length, often determined by direct measurement, serves as a starting point, and subsequent positions are computed through angular observations. The accuracy of triangulation networks depends heavily on precise angle measurements and the stability of the baseline. These networks are particularly suited for large-area mapping, where establishing a framework over extensive regions is necessary.

Trilateration networks, on the other hand, rely on measuring distances directly between points, typically using electronic distance measurement (EDM) techniques. By forming interconnected triangles with known distances, trilateration minimizes the cumulative errors associated with angular measurements. These networks are advantageous when high accuracy in distance measurement is achievable, such as in control surveys for engineering projects. Trilateration tends to be more reliable over shorter distances and is often used in conjunction with triangulation to improve overall network precision.

Traversing networks, also known as traverse surveys, involve establishing a series of interconnected points through a combination of measured angles and distances. Traverses can be open or closed; closed traverses return to the starting point, enabling the detection and correction of measurement errors through mathematical adjustments. These networks are highly flexible, adaptable to various terrains and project scales, and are commonly employed for cadastral surveys, construction layout, and boundary determination. The accuracy of traversing networks depends on the precision of both angular and distance measurements, as well as the quality of the adjustments applied during data processing.

The classification of geodetic networks also considers their intended accuracy and purpose. High-precision networks are designed for scientific and engineering applications where positional accuracy must be within millimeters or centimeters. These include geodetic control networks used in tectonic studies, satellite positioning, and large infrastructure projects. Such networks often employ sophisticated measurement techniques, multiple control points, and rigorous adjustments to minimize errors. Conversely, lower-accuracy networks serve purposes such as topographic mapping at a regional scale, general boundary delineation, or preliminary surveys where a few meters of positional accuracy are sufficient.

The choice of a particular class of geodetic network hinges on several factors: the size of the area to be covered, the required accuracy, available technology, terrain conditions, and budget constraints. For instance, establishing a high-precision control network over a large region may involve a combination of triangulation, trilateration, and traversing, supplemented by modern satellite-based techniques like GPS. In contrast, small-scale projects in accessible terrain might rely solely on traversing with total stations.

In summary, understanding the different types and classes of geodetic networks—triangulation, trilateration, and traversing—and their respective accuracies and purposes is crucial for effective survey planning. High-precision networks are indispensable for scientific and engineering endeavors

demanding millimeter-level accuracy, while lower-precision networks suffice for general mapping and boundary surveys. The selection process involves balancing accuracy requirements, technological capabilities, and logistical considerations to achieve reliable and efficient results in geospatial positioning.

32. Look through the text and say what it is about. (preparation time - 15 min.).

Types of surveys

In geodesy, surveys are fundamental for establishing and maintaining precise measurements of the Earth's surface, which are essential for mapping, construction, navigation, and various scientific applications. There are several main types of surveys, each tailored to specific objectives and employing different methodologies. The primary categories include cadastral surveys, topographic surveys, geodetic surveys, and engineering or construction surveys, among others.

Cadastral surveys focus on defining land boundaries, property lines, and ownership details. These surveys are crucial for legal documentation, land registration, and real estate transactions. They typically involve precise measurements to determine the exact position of boundary markers and often require the integration of historical records, deed descriptions, and field measurements to produce detailed cadastral maps.

Topographic surveys aim to capture the natural and built features of the terrain. They are essential for urban planning, infrastructure development, environmental management, and landscape design. These surveys involve collecting data on elevation, landforms, vegetation, and infrastructure such as roads, buildings, and utilities. The data gathered are used to produce contour maps and 3D models, providing a comprehensive representation of the terrain's surface.

Geodetic surveys are distinguished by their focus on establishing a network of precise control points over large areas. They are fundamental for creating a common framework for various mapping and engineering projects. Geodetic surveys often involve high-precision measurements using techniques such as triangulation, trilateration, and satellite positioning systems like GPS. They are integral to defining the shape and size of the Earth, supporting global navigation systems, and ensuring positional accuracy across large regions.

Engineering or construction surveys are conducted to support the design and construction of infrastructure projects. These surveys provide detailed site data necessary for planning, layout, and execution of construction activities. They include site surveys, quantity surveys, and staking out, which involve marking the positions of structures and features according to engineering plans. These surveys require high accuracy and often combine traditional methods with modern technologies like total stations and laser scanning.

In addition to these main categories, specialized surveys such as hydrographic surveys, which map underwater features; aerial surveys using drones or aircraft for large-scale mapping; and remote sensing techniques, which analyze satellite imagery, are also integral to the field. Each type of survey employs specific tools and methods suited to its objectives, but all share the common goal of acquiring reliable spatial data to support decision-making and scientific understanding.

Overall, the diverse types of surveys in geodesy reflect the broad scope of the discipline, which adapts its methods to meet the demands of various applications, from legal boundary delineation to scientific research and engineering projects. Advances in technology continuously enhance the precision, efficiency, and scope of geodetic surveys, ensuring their vital role in understanding and managing the Earth's surface.

33. Look through the text and say what it is about. (preparation time - 15 min.).

Vertical surveys

Vertical surveys are a fundamental component of geological and geotechnical investigations, playing a crucial role in understanding the subsurface profile of a given area. Unlike horizontal or surface surveys, which primarily focus on the mapping of surface features or horizontal extents, vertical surveys delve beneath the Earth's surface to provide detailed information about the stratigraphy, depth, and composition of subsurface layers. These surveys are essential for a variety of applications, including site investigation for construction projects, mineral and hydrocarbon exploration,

groundwater assessment, and environmental studies.
The primary objective of a vertical survey is to determine the depth and characteristics of different geological layers beneath the ground. This process involves collecting data at various depths to construct a vertical profile or section that illustrates the arrangement, thickness, and nature of subsurface strata. Accurate vertical profiling is critical in ensuring the safety, stability, and feasibility of engineering projects, especially those involving deep foundations, tunnels, or underground facilities.
Several methods are employed in conducting vertical surveys, each suited to specific conditions and objectives. One of the most common techniques is borehole drilling, which involves drilling vertical or inclined holes into the ground to extract continuous samples or to install measurement instruments. Boreholes provide direct access to subsurface materials, allowing geologists and engineers to perform tests such as core sampling, standard penetration tests (SPT), cone penetration tests (CPT), and geophysical logging. These tests yield valuable data about soil and rock properties, including density, strength, moisture content, and mineral composition.
Geophysical methods also play a significant role in vertical surveys, especially when direct drilling is impractical or requires preliminary investigation. Techniques such as electrical resistivity, seismic refraction, and ground-penetrating radar (GPR) can help delineate subsurface features indirectly. For instance, seismic refraction surveys measure the travel time of seismic waves through different layers, allowing the estimation of layer depths and velocities. Electrical resistivity surveys measure the resistance of the ground to electrical currents, which varies with moisture content and material type, providing insights into the layering and potential zones of interest.
The data collected from boreholes and geophysical methods are integrated to create a detailed vertical profile of the subsurface. These profiles are often represented as cross-sectional drawings or logs that illustrate the sequence of geological layers, their depths, and properties. Such profiles assist engineers and geologists in making informed decisions regarding site suitability, foundation design, and risk assessment.
Modern advancements have enhanced the accuracy and efficiency of vertical surveys. Automated logging tools, real-time data acquisition systems, and sophisticated software for data interpretation have significantly improved the quality of subsurface models. Additionally, techniques like downhole geophysical logging allow for continuous measurement of properties along the borehole depth, providing high-resolution data essential for detailed analysis.
Despite their many advantages, vertical surveys also face certain challenges. Drilling and data collection can be costly and time-consuming, particularly in difficult terrain or urban environments. Moreover, the interpretation of geophysical data requires expertise to avoid misrepresentations of subsurface conditions. Nonetheless, the benefits of obtaining reliable subsurface information outweigh these challenges, making vertical surveys an indispensable part of comprehensive geotechnical investigations.
In conclusion, vertical surveys are a vital tool in understanding the Earth's subsurface, enabling safer and more efficient engineering and resource extraction operations. Through a combination of drilling, geophysical techniques, and data integration, these surveys provide detailed insights into the layered structure beneath the surface. As technology continues to advance, vertical survey methods will become even more precise, cost-effective, and accessible, further supporting the development of infrastructure and resource management in a sustainable manner.

34. Look through the text and say what it is about. (preparation time - 15 min.).

Horizontal surveys

Horizontal surveys are a fundamental aspect of land surveying that involves the precise measurement of horizontal distances and angles to determine the relative positions of points on the Earth's surface. These surveys are essential for various applications, including the planning and design of infrastructure projects, land division, boundary determination, construction layout, and environmental studies. The primary objective of a horizontal survey is to establish an accurate framework of points that serve as references for further work or documentation.
The process of conducting a horizontal survey begins with the selection of a suitable survey method based on the project's requirements, terrain conditions, and available equipment. Common methods include chain and tape surveying, plane table surveying, transit and theodolite surveys, and more

advanced techniques like Total Station and GPS surveys. Each method has its advantages and limitations; for example, chain and tape surveying is simple and cost-effective for short distances but less accurate over long spans, whereas modern electronic distance measurement (EDM) instruments and GPS provide higher precision over larger areas.

A typical horizontal survey starts with establishing a control network, which involves selecting prominent points or benchmarks that are accurately known or can be accurately determined through initial measurements. These control points form the basis for subsequent measurements and ensure the survey's overall accuracy. The surveyor then proceeds to measure distances and angles between various points within the survey area, using appropriate instruments. The measurements are carefully recorded, often accompanied by checks and repetitions to minimize errors.

One of the critical challenges in horizontal surveys is maintaining accuracy, which involves meticulous instrument calibration, proper measurement techniques, and correction for possible sources of error such as atmospheric refraction, instrument collimation errors, and earth curvature. Modern instruments like the Total Station combine electronic distance measurement with angular measurement, streamlining data collection and reducing human errors. Additionally, GPS-based surveys utilize signals from satellites to determine positions with high accuracy, especially useful in large or inaccessible terrains.

After data collection, the surveyor processes the measurements through calculations that involve plotting the points on maps or plans. This often includes adjusting the data to account for errors, ensuring that the network is consistent and accurately represents the surveyed area. The final outputs are survey plans, maps, and reports detailing the coordinates and relationships between points. These documents are vital for architects, engineers, land developers, and government authorities to make informed decisions.

Horizontal surveys also involve the use of coordinate systems, such as the local coordinate system or global systems like UTM (Universal Transverse Mercator), to standardize measurements and facilitate integration with other spatial data. The choice of coordinate system depends on the project's scope and requirements.

In conclusion, horizontal surveys are crucial for establishing accurate and reliable spatial data on the Earth's surface. They require careful planning, precise measurement, and diligent data processing to ensure the results are dependable. As technology advances, newer tools and techniques continue to enhance the accuracy, efficiency, and scope of horizontal surveying, making it an indispensable component of modern land management and development projects.

35. Look through the text and say what it is about. (preparation time - 15 min.).

The concept of a datum

In the field of surveying, the concept of a datum is fundamental to ensuring accurate measurement, mapping, and spatial analysis. A datum serves as a reference framework or coordinate system that provides a basis for locating points on the Earth's surface. It establishes a common point of reference from which survey measurements are made, allowing for consistency and precision across different projects and over time. Without a well-defined datum, measurements could be inconsistent, leading to errors in mapping, construction, and other geospatial applications.

There are primarily two types of datums used in surveying: horizontal datums and vertical datums. Horizontal datums define the position of points on the Earth's surface in a two-dimensional plane, providing coordinates such as latitude and longitude or easting and northing in a projected coordinate system. Vertical datums, on the other hand, establish a reference for elevation measurements, indicating the height of points relative to a specific surface, often mean sea level.

Historically, horizontal datums were based on a local reference point, such as a monument or a benchmark, and were often tied to a specific region. As geodesy advanced, global and regional datums were developed to improve consistency across larger areas. For instance, the North American Datum of 1927 (NAD27) and the North American Datum of 1983 (NAD83) are widely used in North America, with NAD83 being more modern and based on a more accurate geocentric coordinate system. Globally, the World Geodetic System 1984 (WGS84) has become the standard datum for GPS and many mapping applications, providing a unified global coordinate framework.

Vertical datums are equally important, especially in construction, drainage, and flood risk assessment. The most common vertical datum is the mean sea level, which acts as a zero-height

reference point. Different regions may have their own local vertical datums, which are sometimes tied to specific tide gauges or benchmarks. For example, in the United States, the National Geodetic Vertical Datum of 1929 (NGVD29) and the North American Vertical Datum of 1988 (NAVD88) are used, with NAVD88 being more recent and based on more accurate measurements.

The choice of a datum depends on the purpose of the survey and the geographic area involved. It's crucial for surveyors to specify the datum used in their measurements, as changing datums can lead to positional differences that may be significant depending on the scale of the project. When data from different sources are combined, transformations between datums are often necessary to ensure compatibility and accuracy. These transformations involve mathematical procedures that adjust coordinates from one datum to another, accounting for differences in the reference points and the underlying models of the Earth's shape.

In practical surveying, modern technology such as GPS relies heavily on the WGS84 datum for positioning. When survey data collected in WGS84 are used for mapping or engineering purposes, they are often transformed into local or project-specific datums to align with existing maps or construction plans. This process underscores the importance of understanding the relationships between various datums and the methods used for datum transformation.

In conclusion, datums are a cornerstone of surveying practice, providing the essential reference framework for accurate spatial measurements. The selection and correct application of the appropriate datum ensure the precision and reliability of survey data, which is vital for a wide range of applications including cartography, construction, land development, and environmental management. As technology advances, the integration of global datums like WGS84 with local datums continues to enhance the accuracy and interoperability of spatial data worldwide.

36. Look through the text and say what it is about. (preparation time - 15 min.).

The Ellipsoid of Rotation: Geodesy's Foundational Model

An ellipsoid of rotation (also called a spheroid or reference ellipsoid) is a mathematically defined surface generated by rotating an ellipse around its minor (shorter) axis. It is characterized by two key parameters: its semi-major axis (a), representing the equatorial radius, and its flattening (f), quantifying the difference between the equatorial and polar radii ($f = (a - b)/a$, where b is the semi-minor axis).

Its Paramount Importance in Geodesy:

1. Mathematical Representation of Earth's Shape: While the Earth's true physical surface is highly irregular (topography, bathymetry) and its gravitational equipotential surface (the geoid) is undulating, the ellipsoid provides a smooth, regular geometric figure that closely approximates the planet's overall bulk shape – an oblate spheroid flattened at the poles and bulging at the equator. This simplicity is essential for mathematical calculations.
2. Reference Surface for Horizontal Datums: The ellipsoid serves as the fundamental reference surface for defining geodetic datums. A datum establishes a coordinate system for precisely locating points on Earth. The ellipsoid provides the geometric framework (shape and size) for the horizontal component (latitude and longitude) of these datums. Examples include WGS84 (used by GPS) or regional datums like NAD83 or ETRS89.
3. Basis for Geodetic Coordinate Systems: Latitude (geodetic latitude, φ) and longitude (λ) are defined relative to the ellipsoid. Geodetic latitude is the angle between the equatorial plane and the normal (perpendicular) to the ellipsoid surface at a point. Longitude is the angle between a reference meridian (e.g., Greenwich) and the meridian plane of the point. Elevation (height) is usually measured separately relative to the geoid (orthometric height) or the ellipsoid (ellipsoidal height).
4. Framework for Calculations: The ellipsoid's well-defined geometry allows precise calculation of:
   Distances and azimuths (directions) between points on its surface.
   Areas of regions projected onto it.
   Transformations between different coordinate systems and datums.
   Reduction of terrestrial survey measurements (angles, distances) from the physical Earth's surface to the regular reference surface.
5. Global Positioning System (GPS/GNSS) Foundation: Satellite positioning systems like GPS fundamentally calculate positions as ellipsoidal coordinates (φ, λ, h - ellipsoidal height) relative to a specific reference ellipsoid (e.g., WGS84 for GPS). This provides a globally consistent geometric

reference frame.
6. Mapping and Charting: Virtually all modern topographic maps, nautical charts, and aeronautical charts are compiled using coordinates referenced to a specific ellipsoid and datum. The ellipsoid provides the stable geometric base onto which the complex physical and cultural features are projected.
In essence: The ellipsoid of rotation is the indispensable geometric foundation of geodesy. It provides the mathematically tractable surface upon which the entire edifice of geodetic datums, coordinate systems, positioning, navigation, and mapping is built. While not the physical Earth or the geoid, its simplicity and close approximation enable the precise mathematical modeling and global referencing essential for accurately describing locations and performing calculations on our planet.

37. Look through the text and say what it is about. (preparation time - 15 min.).

The geometry factor

The geometry factor, often called the Geometric Dilution of Precision (GDOP) or simply geometry, plays a crucial role in precise point positioning (PPP) by quantifying how satellite geometry influences the accuracy of position estimates. In PPP, signals from multiple satellites are used to determine an observer's precise location. The relative positions of these satellites at the time of measurement affect the quality of the position solution.
When satellites are well spread out in the sky, forming wide angles with respect to the receiver, the geometry factor is low, leading to minimal positional error amplification. Conversely, if satellites are clustered together or nearly in a straight line, the geometry factor is high, and the positional errors are significantly amplified. This is because poor geometry causes the errors in satellite range measurements to translate into larger uncertainties in the calculated position.
In mathematical terms, the geometry factor is derived from the covariance matrix of the least squares estimation process. It is influenced by the satellite positions relative to the receiver, which are represented by the line-of-sight (LOS) unit vectors. The design matrix, constructed from these LOS vectors, encapsulates how each satellite's measurement contributes to the solution. The inverse of the normal matrix (the product of the transpose of the design matrix and the design matrix itself) contains the covariance of the estimated position. The GDOP is then calculated as the square root of the trace of this covariance matrix, representing the overall amplification of measurement errors in the position estimate.
In essence, the geometry factor determines how much the measurement noise affects the final position. Better satellite geometry (lower GDOP) results in more accurate and reliable positioning, while poor geometry (higher GDOP) reduces the precision. During PPP processing, the geometry factor is continuously evaluated, and measurements with unfavorable satellite configurations may be weighted less or discarded to improve the robustness and accuracy of the positioning solution.

38. Look through the text and say what it is about. (preparation time - 15 min.).

Regulatory Compliance in construction and ongoing monitoring

Regulatory compliance in construction is a fundamental aspect of ensuring that building projects adhere to established legal standards, safety protocols, and environmental guidelines. It involves a comprehensive understanding of local, regional, and national regulations that govern various facets of construction activities, including planning, design, execution, and post-completion phases. Compliance is not merely a matter of legal obligation but also a critical component in safeguarding the safety of workers, future occupants, and the surrounding community. It helps prevent accidents, structural failures, and legal disputes, thereby promoting sustainable and responsible development.
The process of achieving regulatory compliance begins in the planning and design stages, where architects and engineers must ensure that their plans align with zoning laws, building codes, and environmental regulations. This requires meticulous documentation and submission of permits and approvals before breaking ground. During construction, adherence to safety standards such as OSHA (Occupational Safety and Health Administration) regulations, proper use of personal protective equipment, and implementation of adequate site safety measures are essential to prevent accidents and injuries. Regular inspections are conducted to verify compliance with these standards, and any deviations must be promptly corrected to avoid penalties and project delays.

Ongoing monitoring is a critical element in maintaining compliance throughout the lifecycle of a construction project. It involves continuous oversight and assessment of construction activities to ensure that work remains within the boundaries of regulatory requirements. This can include real-time monitoring of environmental impacts, such as dust, noise, and waste management, as well as safety procedures and quality control measures. Advanced technologies like Building Information Modeling (BIM), drones, sensors, and data analytics are increasingly employed to facilitate real-time tracking and reporting, enabling proactive responses to potential issues before they escalate.

Furthermore, ongoing monitoring ensures that post-construction operations, maintenance, and renovations also comply with relevant standards. Regular audits and inspections are conducted to verify that buildings continue to meet safety and environmental regulations. Any deficiencies identified are addressed through corrective actions, and documentation is maintained for accountability and future reference. This continuous oversight not only helps in maintaining legal compliance but also enhances the longevity and sustainability of the structure.

In addition to technical compliance, regulatory adherence also encompasses contractual and ethical responsibilities. Contractors, developers, and stakeholders must foster a culture of compliance, emphasizing transparency, integrity, and accountability. Training programs and awareness campaigns are vital in ensuring that all personnel understand their roles and responsibilities in maintaining compliance standards.

In conclusion, regulatory compliance in construction is an ongoing, dynamic process that spans the entire project lifecycle. It requires meticulous planning, diligent execution, and continuous monitoring to ensure that all activities meet the necessary legal and safety standards. Embracing technological advancements and fostering a culture of compliance are vital in managing risks and delivering safe, sustainable, and compliant built environments. As regulations evolve in response to new challenges, construction professionals must stay informed and adaptable to uphold the highest standards of compliance, ultimately contributing to the integrity and success of their projects.

39. Look through the text and say what it is about. (preparation time - 15 min.).

Engineering the Sky: The Construction of the Burj Khalifa, Dubai

The Burj Khalifa's rise from the Dubai desert to become the world's tallest structure (828m) stands as a monumental achievement in modern engineering and construction. Its success stemmed from overcoming extreme challenges through innovative design, meticulous planning, and groundbreaking execution. Architect Adrian Smith (SOM) conceived a radical "buttressed core" structural system, inspired by the Hymenocallis flower. Three wings arranged in a Y-shape buttressed a massive central hexagonal core, creating a stable, aerodynamically efficient form tapering upwards. This design minimized wind forces – the critical constraint for super-tall towers – while maximizing usable space.

Foundation and Geodetic Precision: Supporting such unprecedented height required an equally extraordinary foundation. Engineers excavated 50 meters below ground to reach stable strata, constructing a reinforced concrete mat foundation 3.7m thick. Under this sat 194 high-strength barrette piles, plunging over 50m deep into the bedrock, collectively bearing the tower's immense weight (over 500,000 tonnes). Precise positioning of these piles and the core structure was paramount. A sophisticated geodetic control network was established using GPS and high-precision total stations. Crucially, this network included external reference pylons far from the construction zone to ensure stability. Measurements were constantly monitored for thermal expansion effects and adjusted vertically using GPS and precise leveling to maintain millimeter accuracy throughout construction. Laser-guided verticality checks ensured the core remained perfectly plumb.

Vertical Construction Logistics: Pouring the record-breaking height demanded revolutionary concrete technology. A specially designed high-performance, low-permeability concrete mix was developed to withstand Dubai's extreme heat (up to 50°C) and pressure at lower levels. To pump concrete to unprecedented heights, a sophisticated pumping system was engineered. Concrete was placed using high-pressure pumps through a network of pipes, culminating in a single, record-setting pump to 606 meters above ground level. Careful thermal management was critical; ice was added to the mix, and curing was meticulously controlled to prevent thermal cracking in the massive pours. The structure rose using a sophisticated "top-down" approach. A system of self-climbing formwork (jump forms) for the core and wing walls allowed continuous vertical progression. Slipforms were used for the central core, while jump forms moved the perimeter walls upwards section by section. This system

enabled efficient cycle times, with crews working simultaneously on multiple levels.
Cladding and Systems: Installing the 26,000 glass and aluminum curtain wall panels presented another vertical challenge. Custom-designed cradles descended from the top of the completed structure, allowing crews to install the facade progressively downwards as the building rose, maximizing speed and safety. The tower incorporates highly advanced building systems, including a pressurized air supply system for elevators to counteract stack effect, and a complex condensate collection system that recycles water from the air conditioning for irrigation. At its pinnacle sits a massive tuned mass damper, a 350-tonne pendulum system that counteracts wind-induced sway, ensuring occupant comfort and structural integrity during high winds.
Completion and Legacy: Completed in 2010 after six years of construction, the Burj Khalifa redefined the limits of vertical construction. Its success relied on the seamless integration of cutting-edge structural engineering, innovative materials science, unprecedented vertical logistics, and relentless geodetic precision. The project demonstrated the feasibility of super-tall structures in challenging environments and set new benchmarks for global skyscraper design, construction speed, and integrated building systems. It remains an enduring symbol of human ambition and technical ingenuity.

40. Look through the text and say what it is about. (preparation time - 15 min.).

Nord Stream: Engineering a Subsea Megaproject Across the Baltic Sea

The Nord Stream twin natural gas pipelines, stretching 1,224 km through the demanding environment of the Baltic Sea from Russia to Germany, represent one of the most complex subsea infrastructure projects ever undertaken. Completed in 2012 (Line 1) and 2012 (Line 2), their construction pushed the boundaries of offshore engineering, surveying, and environmental management, requiring unprecedented precision across international waters, sensitive ecosystems, and a seabed littered with historical hazards.
Unique Challenges Demanding Innovation:
1. Depth & Route Complexity: The route traversed depths up to 210 meters, crossed busy shipping lanes, navigated around protected marine areas, and avoided thousands of unexploded WWII munitions identified during pre-construction surveys. Precise route planning was critical.
2. Environmental Sensitivity: Minimizing impact on the delicate Baltic Sea ecosystem (e.g., benthic habitats, marine mammals) was paramount. Strict environmental regulations governed every phase.
3. Seabed Variability: The route crossed diverse geology – soft sediments, hard moraines, boulder fields, and glacial erratics – requiring adaptable pipe-laying and burial techniques.
4. Logistical Scale: Millions of tons of materials (concrete-coated steel pipes, rock for protection) were sourced, transported, and installed by a fleet of specialized vessels operating 24/7.
Geodetic & Surveying Triumphs:
Ultra-Precise Route Positioning: A high-accuracy acoustic positioning network, integrated with seabed transponders and vessel GNSS (GPS/GLONASS), guided pipe-laying vessels with centimeter-level precision. Real-time data ensured the pipeline followed the meticulously planned route, avoiding obstacles and adhering to burial depth requirements.
Pre-Lay & Post-Lay Surveys: Sophisticated Multibeam Echosounders (MBES) and Side-Scan Sonar (SSS) mapped the seabed in extreme detail before construction to finalize the route and identify hazards. Post-lay surveys confirmed pipe position, burial depth, and seabed restoration using the same technologies combined with Remotely Operated Vehicles (ROVs) for visual inspection.
Munitions Clearance Verification: High-resolution sonar and magnetometer surveys pinpointed over 80,000 objects. Dedicated vessels meticulously cleared identified munitions along the corridor, with constant surveying verifying safe clearance before pipe-laying proceeded.
Environmental Baseline & Monitoring: Comprehensive pre-construction surveys established ecological baselines. Continuous monitoring during construction tracked sediment plumes, noise levels, and potential impacts using water sampling, acoustic monitoring buoys, and repeated seabed surveys.

Engineering Solutions:
Pipe-Laying Giants: Specialized vessels like the Solitaire and Castoro Sei laid pipes in record time

using the S-lay method, welding sections into continuous strings up to 12 meters long, coating welds, and lowering the pipe to the seabed in a controlled catenary.

Adaptive Burial: Where required (approx. 85% of the route), massive Hydro-Jetting Sleds followed the pipe-lay barge, fluidizing the seabed to bury the pipeline 1-3 meters deep for protection. In rocky areas, pre-trenching or post-lay rock placement was used. Burial depth was continuously monitored via ROVs and sonar.

Material Logistics: Concrete-coated pipes (up to 25 tonnes each) were manufactured in Germany and Finland, shipped to lay barges, and welded continuously. Hundreds of thousands of tons of rock were precisely dumped by fallpipe vessels to stabilize and protect the pipeline sections.

Cross-Border Coordination: Seamless collaboration between Russian, Finnish, Swedish, Danish, and German authorities, surveyors, and contractors was essential for permitting, safety, and environmental compliance along the entire route.

Legacy:

Nord Stream demonstrated that ultra-long, deep-water pipelines through environmentally sensitive and politically complex regions were feasible. It set new standards for:

Subsea Survey Accuracy: Integrating GNSS, acoustics, sonar, and ROVs for unmatched positioning and verification.

Environmental Mitigation: Proving large-scale projects could comply with stringent ecological safeguards through meticulous planning and monitoring.

Offshore Construction Efficiency: Achieving high lay rates in challenging conditions with innovative vessel technology and logistics.

International Project Execution: Managing complex stakeholder interfaces across multiple jurisdictions.

Despite geopolitical shifts impacting its operation, Nord Stream remains a landmark achievement in offshore pipeline engineering and a testament to the power of precision geodetics and integrated project management in conquering one of the world's most demanding marine environments.

41. Answer the question:

What are the key activities during the construction phase?

42. Answer the question:

At what construction phase are topographic and engineering-geodetic surveys conducted?

43. Answer the question:

At what construction phase is staking out/laying out performed?

44. Answer the question:

Are mass earthwork calculations and control included in the planning or construction phases?

45. Answer the question:

Is adherence to plans ensured through geodetic supervision or remote sensing?

46. Answer the question:

What is the aim of an as-built survey?

47. Answer the question:

Are Maintenance, Repair, & Modification Support activities included within the lifespan of the construction project?

48. Answer the question:

What equipment is used at construction sites for geodetic work?

49. Answer the question:

Are Operation & Maintenance activities included in the pre- or post-construction phase?

50. Answer the question:

What is the purpose of deformation monitoring?

51. Answer the question:

Do modifications and repairs require geospatial data?

52. Answer the question:

What methods for collecting construction data are commonly used? (Or: What methods for

collecting construction data are you familiar with?)

53. Answer the question:

What are the core objectives of Engineering Geodetic Support (EGS)?

54. Answer the question:

What is the purpose of quality control within Engineering Geodetic Support (EGS)?

55. Answer the question:

What is meant by the term “efficiency” in the context of Engineering Geodetic Support (EGS)?

56. Answer the question:

Does Deformation Monitoring pertain to the construction or operation phase of an object?

57. Answer the question:

What global navigation satellite system data are used when establishing and maintaining geodetic control networks?

58. Answer the question:

What methods are used for collecting geodetic data at the construction site?

59. Answer the question:

What do we call a specialist responsible for collecting geodetic data at a construction site?

60. Answer the question:

What equipment and software are used to process geodetic data?