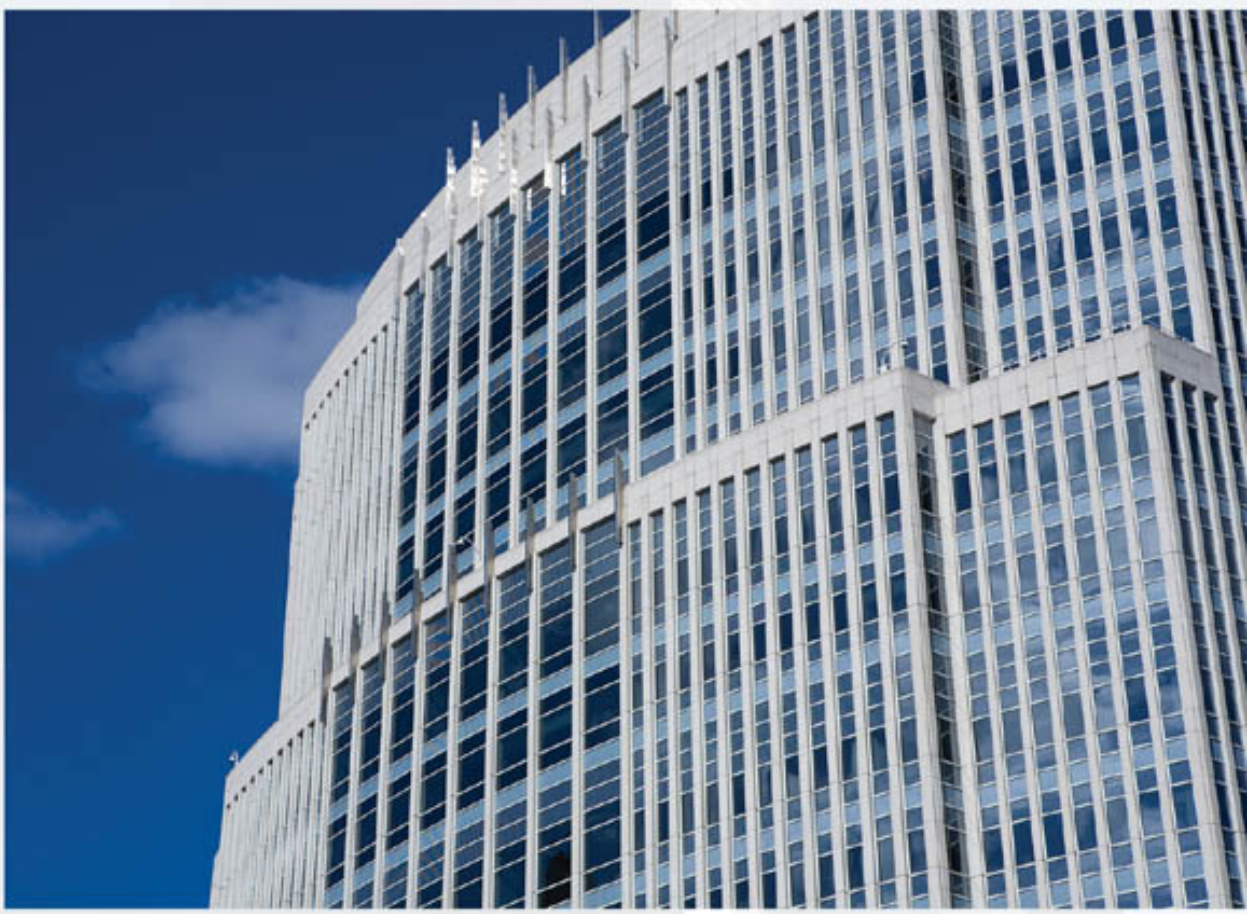
Second Edition

Principles and Practice of Engineering

Architectural Engineering Sample Questions and Solutions



Edited by *Mark McAfee*

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

AEI
ARCHITECTURAL ENGINEERING INSTITUTE

PRINCIPLES AND PRACTICE OF ENGINEERING

Architectural Engineering Sample Questions and Solutions

SECOND EDITION

SPONSORED BY

Professional Exam Development Subcommittee,
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EDITED BY

Mark McAfee

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News and Updates On *www.aeinstitute.org*

For news and updates about the Architectural Engineering Institute, including errata for this publication, visit the AEI Web site at **www.aeinstitute.org.**

News and Updates On *www.ncees.org*

For news and updates about the examinations—including current exam specifications standards, exam policies, calculators approved for use during the examination, exam-day policies, scoring, and other information, visit the NCEES Web site at **www.ncees.org.**

NCEES—The Exam Developer

The Council:

- was established to assist and support its member licensing boards, which are located in each of the states as well as in the District of Columbia, Guam, Puerto Rico, and the Virgin Islands.
- **develops the examinations** required of candidates for licensure as professional engineers. These examinations measure a candidate's ability to demonstrate minimum competency in the practice of engineering and are administered by each NCEES member licensing board.
- follows the guidelines established in the *Standards for Educational and Psychological Testing* published by the American Psychological Association. These procedures maximize the fairness and quality of the examinations. To ensure that the procedures are followed, NCEES **uses experienced testing specialists** who have the expertise to guide the development of examinations using current testing techniques.
- **relies on committees composed of professional engineers** from throughout the nation to prepare the examinations. These licensed engineers—who come from diverse professional backgrounds including government, industry, private consulting, and academia—supply the content expertise that is essential in developing examinations.

Licensing Requirements

Licensure protects the public because it requires candidates to demonstrate certain qualifications before being allowed to practice as an engineering professional.

Eligibility

While examinations offer one means of measuring professional competency, most licensing boards also screen candidates based on education and experience. Because these requirements vary by state, we recommend that candidates contact the appropriate board. Board addresses and telephone numbers are listed on the NCEES Web site.

Application Procedures and Deadlines

Exam application procedures are available from the individual boards. Requirements and fees vary among the boards. Applicants are responsible for contacting their board office. Sufficient time must be allotted to complete the application process and assemble required data.

Description of Examinations

Exam Schedule

The Principles and Practice of Engineering (PE) examination in architectural engineering is offered once each year. The NCEES Web site lists exam dates for the next 10 years. You should contact your board for specific locations of exam sites.

Exam Content

The PE Architectural Engineering exam is an 8-hour, no-choice examination consisting of 80 multiple-choice questions. The examination is administered in two 4-hour sessions, each containing 40 questions.

Because there is no penalty for marking incorrect responses, candidates are advised to answer each question on the examination. Only one response should be marked for each question. No credit is given where two or more responses are marked.

This book presents a complete sample examination. Correct responses require reasoning and calculation demonstrating competent engineering judgment. Because they illustrate the general content covered in the examination, these questions should be helpful in preparing for the examination. Solutions are presented for all questions in this book, although the solution presented may not be the only way to solve a particular question. The intent is to demonstrate the typical effort required to solve each question. No representation is made or intended as to future exam questions, content, or subject matter.

Exam Development and Specifications

To be a valid measure of professional engineering competency, the PE examination must test knowledge pertaining to the specific tasks performed by professional engineers. NCEES ensures this by conducting regular surveys of licensed practitioners. The information gathered from these surveys:

- directs the exam development process
- is used to develop the exam content outline that is presented in the next section of this book
- determines the percentage of questions devoted to each subject area in the exam content outline.

Scoring Procedure

One of the most critical considerations in developing and administering examinations is establishing passing scores that reflect a standard of minimum competency. NCEES defines minimum competency as

> the minimum level of knowledge and skills a person must demonstrate in order to practice engineering and be in responsible charge in a manner that protects the health, safety, and welfare of the public.

Before setting a minimum passing score for a new exam or for the first exam after a change in the specifications or standards, NCEES conducts studies involving a representative panel of engineers familiar with the examinee population. This panel uses procedures widely recognized and accepted for occupational licensing purposes and develops a written standard of minimum competency that clearly articulates what skills and knowledge are required of licensed engineers. Panelists then take the examination, evaluating the difficulty level of each question in the context of the minimum competency standard. Finally, NCEES reviews the panel's work and sets the passing score for the initial exam. For subsequent exams, an equating method is used to set the passing score. The passing (raw) score is never disclosed.

NCEES does not use a fixed-percentage pass rate. The key issue is whether an individual candidate is competent to practice, **not** whether the candidate is better or worse than other candidates. To avoid the confusion that might arise from fluctuations in the passing score, exam results are reported simply as *pass* or *fail*. Some licensing jurisdictions may choose to report exam results of failing candidates as a scaled score.

The legal authority for making licensure decisions rests with the individual licensing boards and not with NCEES.

Exam Policies and Procedures

A breach of an examination could lead to the licensure of people who are not competent to practice engineering. This puts the health, safety, and welfare of the public at risk. Therefore, NCEES takes measures necessary to protect the integrity of the exam process. This includes, for example, restricting cell phones, certain calculators, pencils, loose sheets of paper, and recording devices; controlling access into and out of the exam site; and monitoring activity in and around the exam room. Violating exam policies could result in such measures as dismissal from the exam, cancellation of exam results, and, in some cases, criminal action.

Be sure that you understand the policies outlined in the Candidate Agreement, and read all instructions from your board or testing service before exam day so that you know exactly what the expectations for examinees are.

Candidate Agreement

The Candidate Agreement explains the policies, procedures, and conditions examinees must agree to while taking an NCEES examination. Examinees are required to sign a statement on their answer sheet before the examination starts to affirm that they have been provided the Candidate Agreement, have read and understand the material, and agree to abide by the conditions cited. These conditions apply to all NCEES examinations. A current Candidate Agreement is available on the NCEES Web site.

Special Accommodations

If you require special accommodations in the test-taking procedure, you should contact your state licensing board office well in advance of the day of the examination so that appropriate arrangements may be determined. Only preapproved accommodations are allowed on exam day.

Exam Admission Requirements

For exam admission, examinees must present a current, signed, government-issued photographic identification (such as a valid state driver's license or passport). Student IDs are not acceptable. Examinees must report to the exam site by the designated time. Examinees will not be admitted after the proctor begins reading the exam instructions.

Starting and Completing the Examination

Before the morning and afternoon sessions, proctors will distribute exam books containing an answer sheet. You should not open the exam book until instructed to do so by the proctor. Read the instructions and information given on the front and back covers and enter your name on the front cover. Listen carefully to all the instructions the proctor reads. The proctor has final authority on the administration of the examination.

The answer sheets for the multiple-choice questions are machine scored. For proper scoring, the answer spaces should be blackened completely using only the mechanical pencil provided to you. If you decide to change an answer, you must erase the first answer completely. Incomplete erasures and stray marks may be read as intended answers. One side of the answer sheet is used to collect identification and biographical data that may be used to analyze the performance of the examination.

The biographical data has no impact on the exam results. Proctors will guide you through the process of completing this portion of the answer sheet prior to taking the examination. This process will take approximately 15 minutes.

If you complete the examination with more than 15 minutes remaining, you are free to leave after returning all exam materials to the proctor. If you finish within 15 minutes of the end of the examination, you are required to remain until the end to avoid disruption to those still working and to permit orderly collection of all exam materials. Regardless of when you complete the examination, you are responsible for returning your assigned exam book. Examinees are not allowed to leave until the proctor has verified that all materials have been collected.

References

The PE examination is open-book. Examinees must bring their own reference materials, including design standards. All reference materials must be bound and remain bound during the examination. Individual licensing boards determine the reference materials allowed, so you should contact your board or testing service for specific advice.

Prohibited Items

A current list of prohibited items is included in the Candidate Agreement on the NCEES Web site. If a prohibited item is found in an examinee's possession after the exam begins, or if an examinee is found to be using a writing instrument other than the NCEES-supplied pencil, the item will be confiscated, the examinee will be dismissed from the exam, his or her exam will not be scored, and no refund will be provided. All confiscated items will be sent to NCEES.

Exam Irregularities

Fraud, deceit, dishonesty, and other irregular behavior in connection with taking any NCEES examination is strictly prohibited. Irregular behavior includes but is not limited to the following:

- Copying or allowing the copying of exam answers
- Failing to work independently
- Possessing unauthorized devices or source materials
- Surrogate testing or other dishonest conduct
- Disrupting other examinees
- Creating safety concerns
- Beginning the exam before the proctor instructs you to do so
- Failing to cease work on the examination or put down the pencil when time is called
- Possessing, reproducing, or disclosing exam questions, answers, or other information about the examination without authorization before, during, or after the exam administration
- Communicating with other examinees or with any outside source during the examination by telephone, personal computer, Internet, or any other means

Exam Results

Examinees are understandably eager to find out how they performed on the exam. To ensure that the process is fair and equitable to examinees and to maintain the validity of the exam questions, NCEES uses a rigorous scoring process for each of the NCEES multiple-choice examinations that takes approximately 12 weeks to complete.

- First, NCEES scans all answer sheets as they are received from the states. Answer sheets are flagged for review when they are missing critical information, such as one of sessions examinees worked or the candidate ID number. The scoring process continues only when these issues are resolved.
- Next, a psychometric analysis is performed on a sample population of answer sheets from each multiple-choice examination to identify any questions with unusual statistics, which flag the question for review.
- Then, at least two subject-matter experts who are licensed engineers review the flagged items. In addition, NCEES reviews all Candidate Comment Forms, and the subject-matter experts consider comments on the forms about specific exam questions. If the reviews confirm an error in a question, credit may be given for more than one answer.
- When the analyses and reviews are completed, NCEES revises the answer keys as necessary. The passing score and the final correct answers for each exam are then used to score all the answer sheets. Scanners are calibrated before and during scoring. A percentage of the answer sheets are hand-graded and the results compared to the machine score to ensure accuracy of results.
- Finally, NCEES releases the results to the state boards or testing agencies, who in turn report the results to examinees.

Principles and Practice of Engineering

Architectural Engineering Exam Specifications

National Council of Examiners for Engineering and Surveying
Effective Beginning with the April 2010 Examinations

Approximate Percentage of Examination

I. Building Systems Integration — 17%

A. Aspects of building performance that affect human comfort (e.g., vibration, noise, lighting, climate control)
B. Building envelope analysis
C. Impact of one system on another (e.g., lighting load on air-conditioning system capacity)
D. Life safety systems (e.g., generators, batteries, exit lighting, fire alarms)
E. Systems efficiencies (including calculations for energy usage and costs such as life cycle, material)
F. Sustainability (e.g., energy efficiency, renewable energy, indoor air quality, water conservation)
G. Applicable standards, codes, and regulations (e.g., NFPA; ASHRAE; ICC; ADA requirements)
H. Design and construction issues associated with commissioning process, including testing and balancing

II. Electrical Systems — 25%

A. Electrical power systems analysis, including load flow
B. Short circuit analysis
C. Grounding principles
D. Electrical construction methods and materials (new and existing systems)
E. Overcurrent protection methods and device coordination
F. Branch circuit and feeder conductor sizing
G. Power distribution for building systems and equipment
H. Voltage drop calculations
I. One-line diagram
J. Fire alarm device layout
K. Light source selection considering elements such as type, color, life, cost, efficiency, and application
L. Lighting calculations (e.g., lumen method, light at a point)
M. Lighting control
N. Receptacle layout
O. Equipment and component selection

III. Mechanical Systems 25%

A. Fan laws
B. Pump laws
C. Flow and riser diagrams
D. Static pressure calculations (air and water)
E. Materials and methods (e.g., new and existing ductwork, piping materials, and insulation)
F. Piping for specialty systems (e.g., fuel oil, natural gas, medical gas)
G. Pipe expansion (e.g., expansion joints, loops, anchors)
H. Heat gain and loss calculations
I. Psychrometrics
J. Hydronic and steam systems
K. Equipment selection (e.g., pumps, air handling units, chillers, boilers)
L. HVAC system analysis and selection (e.g., air cooled/water cooled, all air, heat pumps, split systems)
M. Fire protection sprinkler and standpipe classifications
N. Ventilation
O. Indoor air quality
P. Air distribution
Q. Domestic water systems (routing, sizing)
R. Stormwater systems
S. Sanitary waste and vent systems (routing, sizing, slope)
T. Sequences of operation for building controls

IV. Structural Systems 25%

A. Types of construction (e.g., structural steel, timber, concrete, masonry)
B. Components (e.g., tension, compression, bending, shear)
C. Structural load effects on overall electrical, mechanical, and structural systems (e.g., seismic, wind, thermal, vibrations)
D. Connections (e.g., bolted, welded, base plates, brackets)
E. Loads (e.g., gravity, lateral, temperature, settlement, construction)
F Analysis of frames and shear walls
G. Analysis of construction systems (e.g., new and existing staging, bracing, and loads)
H. Analysis of stability
I. Analysis of deflection
J. Foundations (e.g., piles, shafts, spread)
K. Materials characteristics (e.g., strength, stiffness, hardness, environmental concerns, fatigue concerns) of steel, concrete, masonry, and timber

V. Project Management and Construction Administration 8%

A. Discovered site conditions
B. Change orders
C. Alternates
D. Request for information
E. Architectural supplemental information (e.g., RFI response, clarification in construction documents, bulletins)
F. System conflict resolution
G. Scheduling of design tasks, sequence of activities, CPM
H. Progress reports
I. Quality control
J. Contract administration
K. Legal issues (e.g., contracts; impact of decisions that may result in lawsuit; errors and omissions)
L. Construction safety
M. Submittal processes

TOTAL 100%

Notes

1. The knowledge areas specified as examples of kinds of knowledge are not exclusive or exhaustive categories.
2. This exam contains 80 multiple-choice questions. Examinee works all questions.

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Sample Questions for the Morning Portion of the Examination in Architectural Engineering

Test Items 101-140

101. In a high rise office building, which of the following groups of systems are typically required by building codes to have emergency power for life safety reasons?

    a. Elevator shaft exhaust fans, egress corridor lighting, temperature controls.
    b. Stair pressurization fans, exit lights, egress corridor lighting.
    c. Fire alarm system, egress corridor lighting, telephone system.
    d. Fire alarm system, exit lights, exit stair exhaust fans.

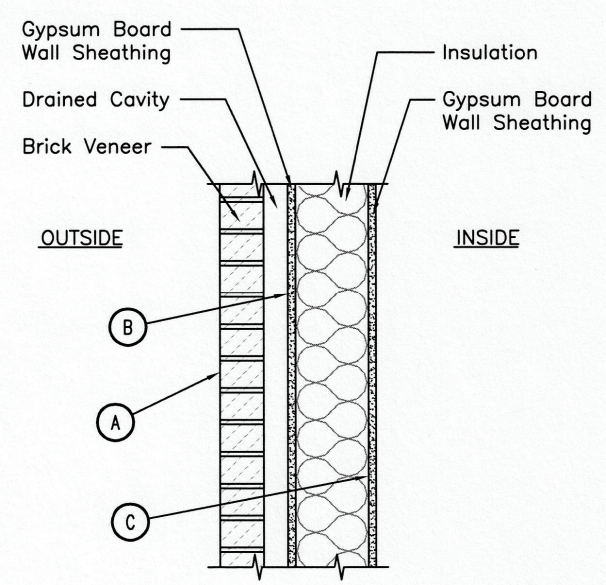
102. When selecting the roof location for a plumbing vent, which of the following design elements should be taken into consideration?

    a. The location of exhaust fan outlets.
    b. The location of other plumbing vents.
    c. The location of roof-top fire hose connections.
    d. The location of outside air intakes for the HVAC system.

103. In a high rise building, the HVAC system should respond to a fire alarm in which of the following ways:

    a. Pressurize the elevator shafts and exit stairways.
    b. Pressurize only the elevator shafts.
    c. Exhaust the elevator shafts.
    d. Exhaust the exit stairways.

For Question 104, refer to the wall section below:



104. Using the given wall sections in a hot and humid climate where is the best location for the vapor barrier to be placed to keep outside air from entering the wall cavity, where moisture could condense in the summertime?

    a. On the exterior face of the brick
    b. On the exterior side of the sheathing within the drained cavity
    c. On the inside face of the insulation adjacent to the gypsum board sheathing
    d. All of the above locations

105. A fan motor consumes 40 kilowatts of power, operates 2,080 hours per year and delivers 35,000 CFM (constant volume). The air distribution system is converted to variable air volume and the same fan supplies an annual average of 20,000 CFM at the same static pressure. The annual amount of energy saved, assuming $0.08 kW-h, is most nearly:

    a. $6,650
    b. $5,420
    c. $4,480
    d. $2,850

106. An 8-inch thick lightweight CMU block wall has been installed between a manufacturing area and an adjacent office area. An unsatisfactory amount of noise from the manufacturing area can be heard in the office area. Which of the following wall construction modifications would be most beneficial in reducing the sound transmission through the wall.

    a. Fill the CMU block cores solid with sand
    b. Add a 1/2” thick plaster coating to each face of CMU wall
    c. Add 5/8” gypsum board sheathing and 2 x 4 wood furring studs rigidly attached to each face of CMU wall
    d. Add 5/8” gypsum board sheathing and metal furring resiliently attached to each face of CMU wall

107. Using Table 1.1 and Table 11.5-1 from the ASCE 7-05 below, which of the following building occupancy types would have the largest calculated seismic force if the building structure, size, weight, and location were the same?

    a. Elementary school with an occupancy of 500
    b. Telecommunications center
    c. Office building
    d. Police station

TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with daycare facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generating stations[a] • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

[a] Cogeneration power plants that do not supply power on the national grid shall be designated Occupancy Category II.

TABLE 11.5-1 IMPORTANCE FACTORS

Occupancy Category	*I*
I or II	1.0
III	1.25
IV	1.5

Source: ASCE 7-05.

108. The term for the ratio of the Luminance leaving a surface area to the Illuminance arriving on the surface is:

    a. Exitance
    b. Transmittance Factor
    c. Luminance Factor
    d. Luminous Flux

109. In a balanced 3 phase circuit, the voltage, V_{LN}, equals 120V $\angle 0°$. The phase sequence is “a”,”b”,”c”. The current (A) in I_{LN} of a wye-connected load having a Z_L $=2\Omega \angle 40°$ (ohms) is most nearly:

    a. $60 \angle 40°$
    b. $60 \angle -40°$
    c. $240 \angle 40°$
    d. $240 \angle -40°$

For **Question 110**, refer to the table below.

MOTOR FULL LOAD CURRENTS

(Amperes)

HP	1 Φ				3 Φ				
	115 V	120 V	208 V	230 V	208 V	230 V	460 V	480 V	575 V
1/33	1.7	1.7	1.0	0.9	--	--	--	--	--
1/20	1.9	1.9	1.1	1.0	--	--	--	--	--
1/15	2.1	2.0	1.2	1.0	--	--	--	--	--
1/12	2.3	2.2	1.3	1.2	--	--	--	--	--
1/8	3.1	3.0	1.7	1.6	--	--	--	--	--
1/6	4.4	4.2	2.4	2.2	--	--	--	--	--
1/4	5.8	5.6	3.2	2.9	--	--	--	--	--
1/3	7.2	6.9	4.0	3.6	--	--	--	--	--
1/2	9.8	9.4	5.4	4.9	2.4	2.2	1.1	1.1	0.9
3/4	--	--	7.6	6.9	3.5	3.2	1.6	1.5	1.3
1	--	--	8.8	8.0	4.6	4.2	2.1	2.0	1.7
1-1/2	--	--	11.0	10.0	6.6	6.0	3.0	2.9	2.4
2	--	--	13.2	12.0	7.5	6.8	3.4	3.3	2.7
3	--	--	18.7	17.0	10.6	9.6	4.8	4.6	3.8
5	--	--	30.8	28.0	16.8	15.2	7.6	7.3	6.1
7-1/2	--	--	44.0	40.0	24	22	11	11	9
10	--	--	55.0	50.0	31	28	14	13	11
15	--	--	--	--	46	42	21	20	17
20	--	--	--	--	60	54	27	26	22
25	--	--	--	--	75	68	34	33	27
30	--	--	--	--	88	80	40	38	32
40	--	--	--	--	115	104	52	50	42
50	--	--	--	--	144	130	65	62	52

110. A single motor branch circuit is to be used to serve three motors rated at 1/3HP, 1/2HP, and 1/4HP. The motors are operating on a 115 volt, 60 hertz, single phase circuit. Using the given table, the calculated full load amps (A) that will be used to size the feeder for this branch circuit according to the National Electric Code is most nearly:

a. 22.8
b. 25.3
c. 27.7
d. 29.4

For **Question 111**, refer to the following information.

Given Information:

	Phase A	Phase B	Phase C
Lighting	50 kVA	40 kVA	45 kVA
Receptacles	10 kVA	20 kVA	15 kVA
Other Continuous Loads	20 kVA	25 kVA	25 kVA

111. A three phase panel for an office building is described above. Using the National Electric Code defined demand factors, the total kVA load on this panel is most nearly:

a. 232.5
b. 250.0
c. 273.75
d. 301.25

For **Question 112**, refer to the following information.

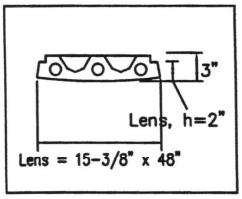
Given Information:

3 phase
13,200-277/480V
1500 kVA
5.5% Impedance

112. For the transformer described above, the full load current (A) available at the secondary terminals of the transformer is most nearly:

a. 27,272
b. 5,415
c. 3,125
d. 1,804

For **Question 113**, refer to the photometric data sheet below.



PHOTOMETRIC DATA
Luminaire –"BAE3T8A"

DESCRIPTION:
15 x 48 Prismatic Fluo.
Wraparound with
Metal Ends
LAMP: 3F32T8/35 VOLTS120
TF: 1.0 BF: .88 Watts: 87
LUMEN/LAMP 2900 DATE2000
SHIELDING ANGLE: N 90 L 90
BARE 2350 FILE BAE332
TEST NO. 8365TL BY: RNH

OUTPUT DATA

ZONES	LUMENS	%TOT. LAMP	%TOT. DIST.
0– 40°	2935		
40– 90°	2900		
90–180°	669		
0–180°	6504		

LUMINANCE DATA

ANGLE	ALONG			ACROSS		
	MAX.	AVE.	M/A	MAX.	AVE.	M/A
45	2670			3670		
55	2052			2540		
65	1455			1825		
75	1045			1650		
85	785			1535		

LUMINOUS INTENSITY

	ALONG	22.5	45.0	67.5	ACROSS
0	2237	2237	2237	2237	2237
5	2229	2235	2239	2233	2224
15	2150	2166	2184	2197	2192
25	1987	2019	2073	2112	2112
35	1706	1764	1856	1898	1895
45	1295	1342	1421	1478	1486
55	822	832	871	912	922
65	467	421	430	496	568
75	261	244	255	365	442
85	83	112	202	340	391
90	7	52	176	325	371
95	5	41	164	291	329
105	19	54	157	233	260
115	27	52	121	188	199
125	38	59	95	125	142
135	48	59	66	91	97
145	46	57	61	66	61
155	40	57	55	59	61
165	38	34	43	43	40
175	30	33	30	32	35
180	32	32	32	32	32

ZONES – 5 degrees

DOWN HEMISPHERE	UP HEMISPHERE	ZONAL CONSTANT
0 – 5	175 –	0.024
5 – 10	170 – 175	0.072
10 – 15	165 – 170	0.119
15 – 20	160 – 165	0.165
20 – 25	155 – 160	0.210
25 – 30	150 – 155	0.253
30 – 35	145 – 150	0.295
35 – 40	140 – 145	0.334
40 – 45	135 – 140	0.370
45 – 50	130 – 135	0.404
50 – 55	125 – 130	0.435
55 – 60	120 – 125	0.462
60 – 65	115 – 120	0.486
65 – 70	110 – 115	0.506
70 – 75	105 – 110	0.523
75 – 80	100 – 105	0.535
80 – 85	95 – 100	0.543
85 – 90	90 – 95	0.548

ZONAL CONSTANTS

ZONES – 10 degrees

DOWN HEMISPHERE	UP HEMISPHERE	ZONAL CONSTANT
0 – 10	170 – 180	0.095
10 – 20	160 – 170	0.283
20 – 30	150 – 160	0.463
30 – 40	140 – 150	0.628
40 – 50	130 – 140	0.774
50 – 60	120 – 130	0.897
60 – 70	110 – 120	0.993
70 – 80	100 – 110	1.058
80 – 90	90 – 100	1.091

113. Using the given photometric data sheet, the value of the “Zonal Lumens” for the elevation angle of 75 degrees from nadir is most nearly:

a. 303.9
b. 321.5
c. 331.6
d. 350.8

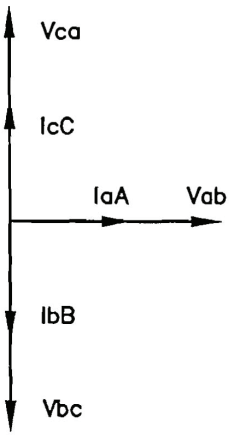
For **Question 114**, the following balanced 3 phase loads are connected to a 3 phase, 4 wire, 480V/277, 60 Hertz distribution:

1. 4-three phase induction motors of 10 HP each operating at full load with 90% efficiency and 85% PF.
2. 1-80 kVA heating load at a Lagging, PF=.92.
3. 3-single phase, 10 kW lighting loads each at unity power factor.

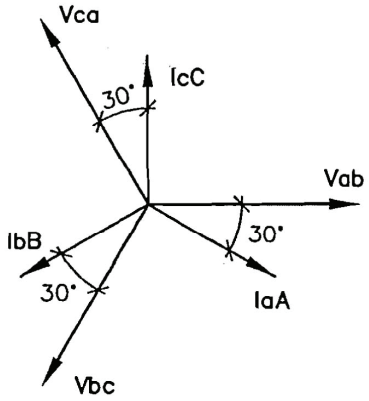
114. The amount of Capacitive Reactance power, in kVAR, that must be added to the system to yield an overall system power factor of 98% Lagging is most nearly:

a. 16.65
b. 24.13
c. 26.50
d. 31.35

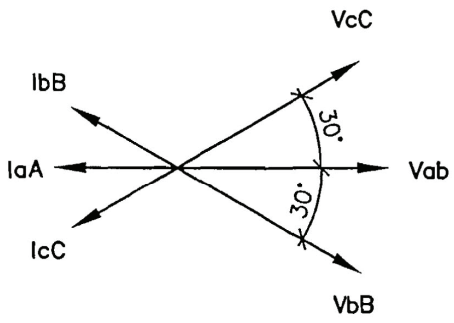
For **Question 115**, refer to the phasor diagrams below.



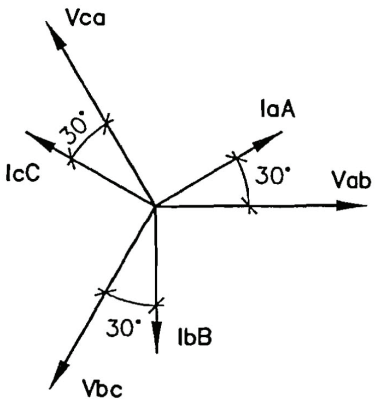
Vector Diagram A



Vector Diagram B



Vector Diagram C



Vector Diagram D

115. Given the above phasor diagrams for a 3 phase system, where the current lags the voltage by 30E, the correct phasor diagram is most nearly:

    a. Vector diagram A
    b. Vector diagram B
    c. Vector diagram C
    d. Vector diagram D

116. For rigid metal conduit, according to the National Electric Code, the correct statements regarding bending requirements are most nearly:

    I. There shall be not more than the equivalent of four quarter bends between pull points.

    II. There shall be not more than 180 degrees of total bends between pull points.

    III. There shall be not more than four bends of any angle between pull points.

    IV. There shall be not more than 360 degrees in bends between pull points.

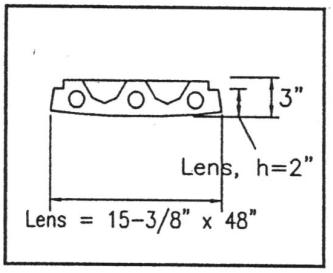
    V. There shall be not more than the equivalent of four 45 degree bends between pull points.

    a. I and IV only
    b. I,III and IV only
    c. II,III and V only
    d. II and V only

For **Question 117**, refer to the Photometric Data Sheet and the design factors given below.

PHOTOMETRIC DATA

Luminaire –"BAE3T8B"



DESCRIPTION:
15 x 48 Prismatic Fluo.
Wraparound with
Metal Ends
LAMP: 3F32T8/35 VOLTS 120
TF: 1.0 BF: .88 Watts: 87
LUMEN/LAMP 2900 DATE 2000
SHIELDING ANGLE: N 90 L 90
BARE 2350 FILE BAE332
TEST NO. 8365TL BY: RNH

CATEGORY V

LUMINANCE DATA

ANGLE	ALONG			ACROSS		
	MAX.	AVE.	M/A	MAX.	AVE.	M/A
45	2670			3670		
55	2052			2540		
65	1455			1825		
75	1045			1650		
85	785			1535		

OUTPUT DATA

ZONES	LUMENS	%TOT. LAMP	%TOT. DIST.
0– 40°	2935		
40– 90°	2900		
90–180°	669		
0–180°	6504		

FLOOR, ρ_{fc}		COEFFICIENT OF UTILIZATION, ρ_{fc} = 20%			
CLNG., ρ_{cc}		80	70	50	0
WALL, ρ_w		70 50 30	70 50 30	50 30 10	0
ROOM CAVITY RATIO	1	80 77 74	77 74 71	70 67 65	57
	2	74 68 63	71 68 62	62 59 56	49
	3	68 61 55	65 59 54	56 51 48	43
	4	63 54 48	60 53 47	50 45 42	37
	5	57 49 42	55 47 41	45 40 36	32
	6	53 44 37	51 43 37	41 35 32	28
	7	49 39 33	47 38 33	37 32 28	25
	8	45 35 29	44 35 29	33 28 24	22
	9	42 32 26	40 31 25	30 25 21	18
	10	39 29 23	37 28 23	27 22 19	16

Luminaire Spacing Criterion = 1.2/1.3

Given Information:

Room: Width = 14 Feet Length = 28 Feet Floor-to-ceiling = 8 Feet

Workplane = 2.5 Feet

Surface Mounted Luminaire, hcc = 0

Surface Reflectances:
Ceiling = 70% Walls = 50% Effective Reflectance of the Floor Cavity, ρ_{fc} = 20%

Recommended Illuminance Level, E_r = 75 fc

Maintenance Data: LLD = .86 LDD = .70

117. Using the given Photometric Data sheet and design factors, the number (round to whole number) of luminaires required to produce the average, uniform, maintained illuminance level is most nearly:

    a. 11
    b. 12
    c. 13
    d. 14

118. Which of the following most nearly describes how plumbing vents should be sloped to comply with the International Plumbing Code?

    a. Vent lines are not required to be sloped.
    b. Plumbing vents should be sloped to drain back to the soil or waste pipe by gravity, at any amount of slope.
    c. Vent lines must be sloped toward the vent cleanout.
    d. Vent lines must be sloped a minimum of 1/4" per foot towards the soil or waste stack.

119. Which of the following is NOT a scheme used to protect cooling towers from freezing?

    a. Variable frequency drive on the condenser pump
    b. Glycol in the condenser water
    c. Condenser by-pass with a remote sump
    d. Heat trace the sump with basin heaters

120. A building that is to have a room temperature of 75 degrees F, has a supply air temperature of 105 degrees F. If the net heat loss from the building is 162,000 BTU per hour, the air flow (CFM) that must be supplied at standard air pressure is most nearly:

    a. 5,400
    b. 5,000
    c. 2,160
    d. 1,542

For **Questions 121-122** , refer to the following information.

A mechanically induced draft cooling tower is used to reject heat from an air conditioning system's water chiller. The chiller has a capacity of 600 tons of refrigeration.

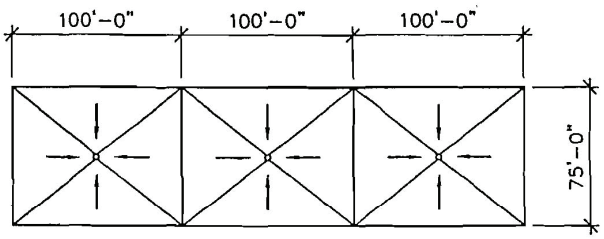
121. At 75% load, the energy input is 0.70 kW per ton. The heat rejected to the cooling tower (Btu/hr) at this condition is most nearly:

    a. 5,056,000
    b. 5,400,000
    c. 6,475,000
    d. 7,550,000

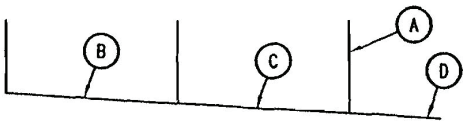
122. It is desired to use a two-speed motor on the cooling tower fan to save energy at part load conditions. The best way to save energy is achieved by controlling the fan speed from:

    a. Cooling tower entering air temperature
    b. Cooling tower leaving water temperature
    c. Leaving chilled water temperature
    d. Condenser leaving water temperature

For **Question 123**, refer to the roof plan, riser diagram, and tables below.



Roof Drainage Plan – Figure 1



Storm Riser Diagram – Figure 2

The roof plan for a building with three internal storm drains is shown in Figure 1, while the storm riser diagram in shown in Figure 2. The four pipe sections are labeled in the riser diagram, i.e. A, B, C, and D. The pipe section B, C, D is sloped downward at a rate of $\frac{1}{4}$ inches per foot.

SIZE OF VERTICAL CONDUCTORS AND LEADERS

DIAMETER OF OF LEADER (inches)[a]	HORIZONTALLY PROJECTED ROOF AREA (square feet)											
	Rainfall rate (inches per hour)											
	1	2	3	4	5	6	7	8	9	10	11	12
2	2,880	1,440	960	720	575	480	410	360	320	290	260	240
3	8,800	4,400	2,930	2,200	1,760	1,470	1,260	1,100	980	880	800	730
4	18,400	9,200	6,130	4,600	3,680	3,070	2,630	2,300	2,045	1,840	1,675	1,530
5	34,600	17,300	11,530	8,650	6,920	5,765	4,945	4,325	3,845	3,460	3,145	2,880
6	54,000	27,000	17,995	13,500	10,800	9,000	7,715	6,750	6,000	5,400	4,910	4,500
8	116,000	58,000	38,660	29,000	23,200	19,315	16,570	14,500	12,890	11,600	10,545	9,600

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929 m^2.

a. Sizes indicated are the diameter of circular piping. This table is applicable to piping of other shapes provided the cross-sectional shape fully encloses a circle of the diameter indicated in this table.

SIZE OF HORIZONTAL STORM DRAINGE PIPING

SIZE OF HORIZONTAL PIPING (inches)	HORIZONTALLY PROJECTED ROOF AREA (square feet)					
	Rainfall rate (inches per hour)					
	1	2	3	4	5	6
	$^1/_8$ unit vertical in 12 units horizontal (1-percent slope)					
3	3,288	1,644	1,096	822	657	548
4	7,520	3,760	2,506	1,800	1,504	1,253
5	13,360	6,680	4,453	3,340	2,672	2,227
6	21,400	10,700	7,133	5,350	4,280	3,566
8	46,000	23,000	15,330	11,500	9,200	7,600
10	82,800	41,400	27,600	20,700	16,580	13,800
12	133,200	66,600	44,400	33,300	26,650	22,200
15	218,000	109,000	72,800	59,500	47,600	39,650
	$^1/_4$ unit vertical in 12 units horizontal (2-percent slope)					
3	4,640	2,320	1,546	1,160	928	773
4	10,600	5,300	3,533	2,650	2,120	1,766
5	18,880	9,440	6,293	4,720	3,776	3,146
6	30,200	15,100	10,066	7,550	6,040	5,033
8	65,200	32,600	21,733	16,300	13,040	10,866
10	116,800	58,400	38,950	29,200	23,350	19,450
12	188,000	94,000	62,600	47,000	37,600	31,350
15	336,000	168,000	112,000	84,000	67,250	56,000
	$^1/_2$ unit vertical in 12 units horizontal (4-percent slope)					
3	6,576	3,288	2,295	1,644	1,310	1,096
4	15,040	7,520	5,010	3,760	3,010	2,500
5	26,720	13,360	8,900	6,680	5,320	4,450
6	42,800	21,400	13,700	10,700	8,580	7,140
8	92,000	46,000	30,650	23,000	18,400	15,320
10	171,600	85,800	55,200	41,400	33,150	27,600
12	266,400	133,200	88,800	66,600	53,200	44,400
15	476,000	238,000	158,800	119,000	95,300	79,250

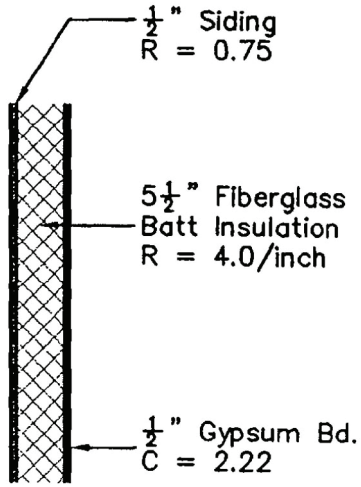
For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929 m^2.

Source: 2006 International Plumbing Code. Reprinted by permission of the International Code Council, www.iccsafe.org.

123. Using the given roof plan, riser diagram, and tables, and assuming a rainfall rate of 5 inches per hour, the required nominal size (inches) of the vertical riser, Section A, is most nearly:

    a. 2
    b. 3
    c. 4
    d. 6

For **Question 124**, refer to the section below.



124. In the given wall section, assume that there are 2" by 6" wood studs at 24" on center (R= 1.0 / inch). Neglect the interior and exterior film coefficients. The overall U-value for the given wall-section is most nearly:

    a. 0.033
    b. 0.043
    c. 0.050
    d. 0.149

125. Ordinary-temperature sprinklers are rated for use in what temperature range?

    a. 135°F to 170°F
    b. 175°F to 225°F
    c. 250°F to 300°F
    d. 350°F to 450°F

For **Question 126**, refer to the sketch and Friction Loss Chart below.

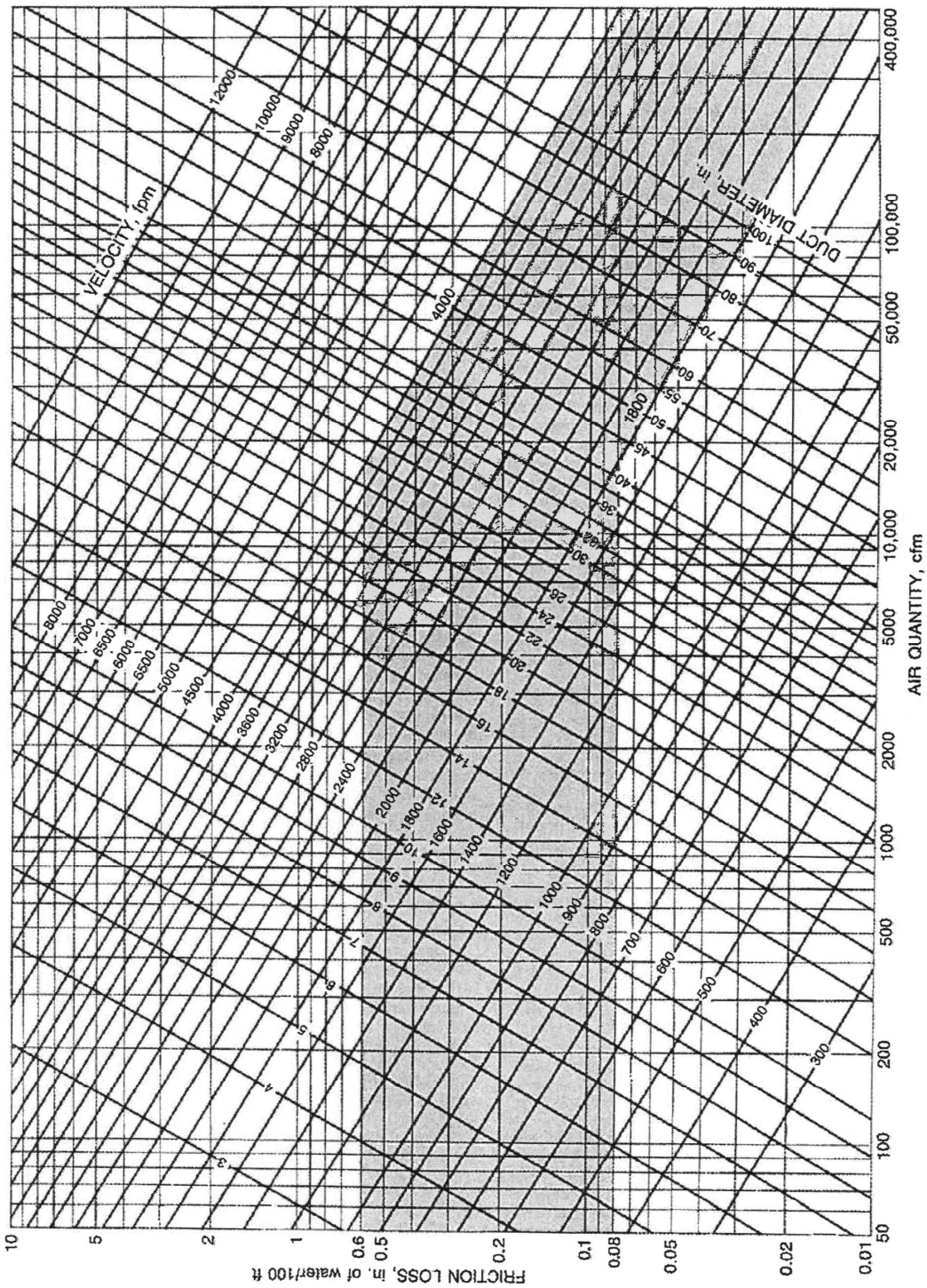
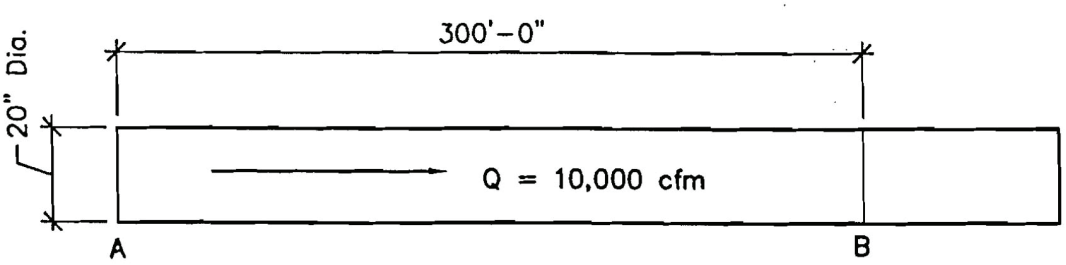


Fig. 9 Friction Chart for Round Duct ($\rho = 0.075$ lb$_m$/ft^3 and $\varepsilon = 0.0003$ ft)

Source: 2009 ASHRAE Handbook—Fundamentals. Reprinted by permission of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. Copyright 2009 ASHRAE.



126. Using the given sketch and the Friction Loss Chart, if the total pressure at point A is 6.00 inches of water gauge, the static pressure in the round duct at Point B is most nearly:

    a. 1.14 inches of water gauge
    b. 2.4 inches of water gauge
    c. 3.5 inches of water gauge
    d. 4.8 inches of water gauge

127. The best way to control the fan supply pressure for a variable air volume HVAC System is to:

    a. Install a static pressure sensor 2/3 of the way down the main duct.
    b. Install a static pressure sensor at the discharge of the supply fan.
    c. Install a static pressure sensor at the fan inlet and discharge.
    d. Install a static pressure sensor at the fan inlet.

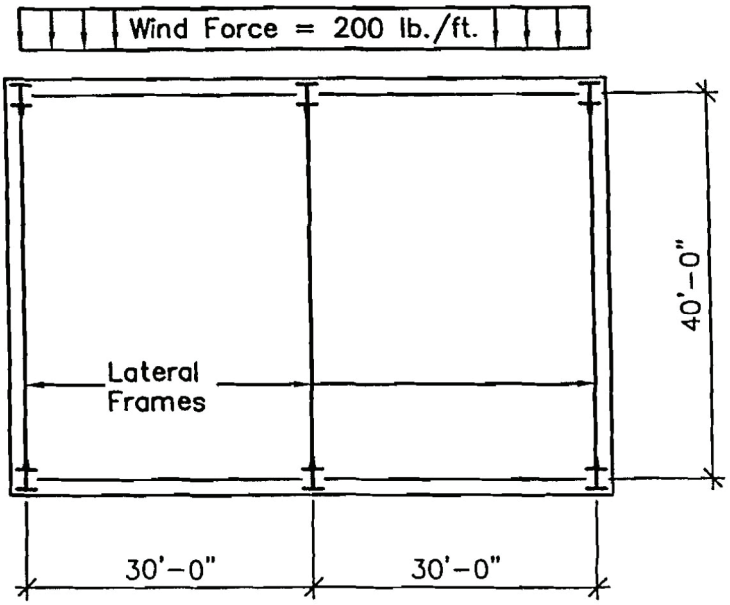
128. Which of the following DOES NOT influence the structural performance of a reinforced concrete beam during a fire?

    a. Concrete coverage of reinforcing.
    b. Density of concrete.
    c. Concrete compressive strength.
    d. Concrete aggregate type.

129. In general, which of the following is the LEAST efficient frame in limiting drift from lateral loads?

    a. Moment resisting frame.
    b. X-Braced Frame.
    c. K-Braced Frame
    d. Shear Wall

For **Question 130**, refer to the roof plan below.



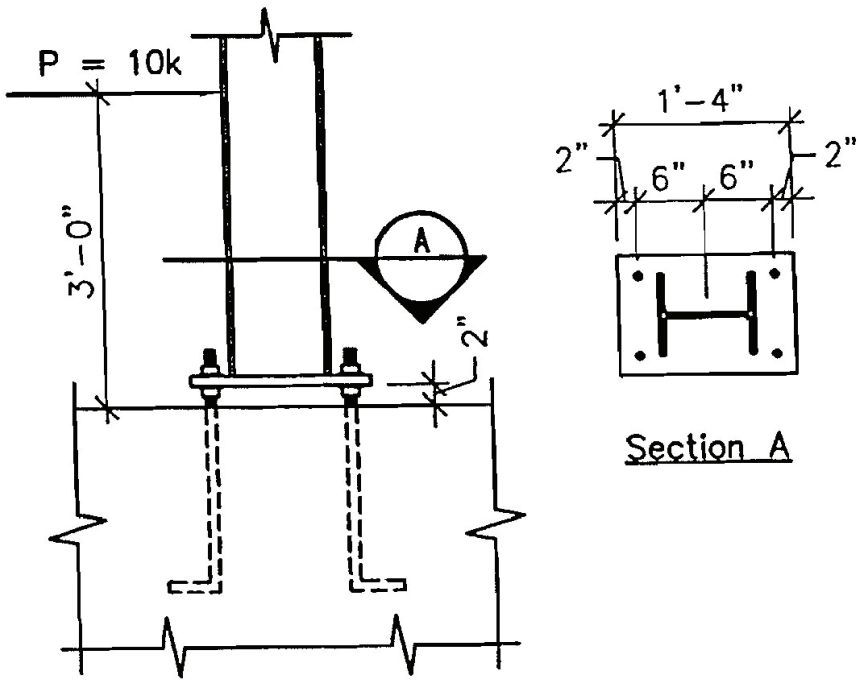
130. Using the given roof plan and a lateral wind force of 200#/ft. applied at the roof level, the maximum required capacity of the flexible roof diaphragm (#/ft.) is most nearly:

    a. 50
    b. 75
    c. 100
    d. 150

131. A 7 feet by 7 feet square footing resists a service axial load of 100k and a service overturning moment of 50 ft-k. The maximum soil pressure (ksf) under the footing, neglecting the weight of the footing, is most nearly:

    a. 1.17
    b. 2.04
    c. 2.92
    d. 3.06

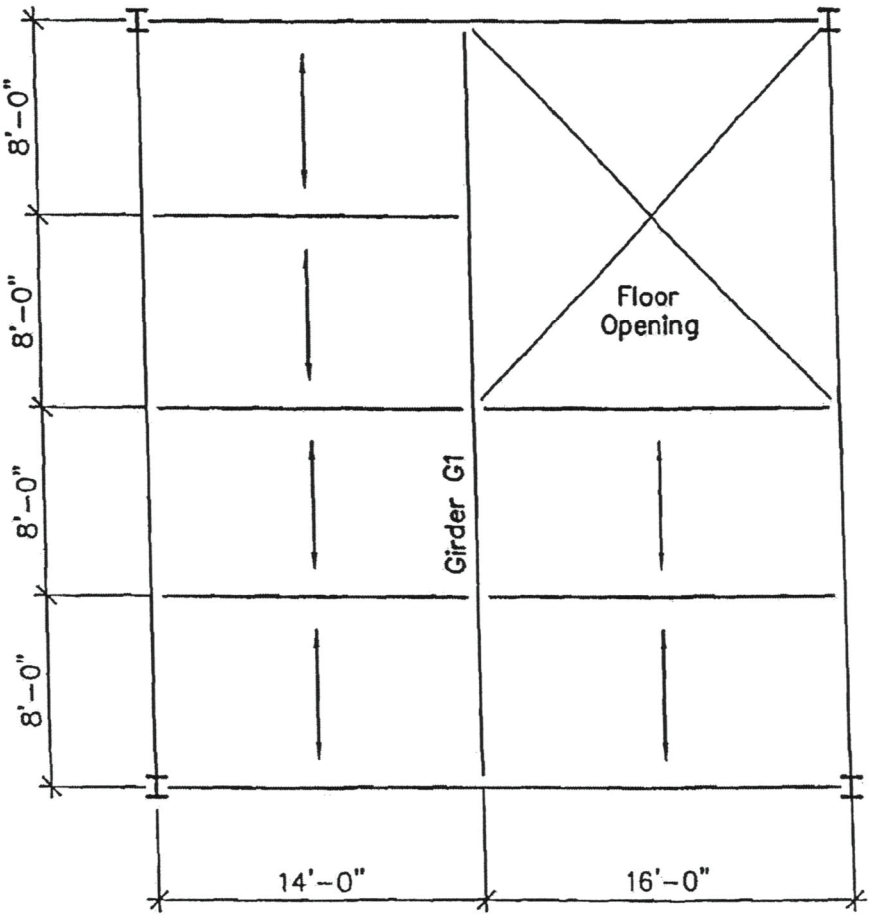
For **Question 132**, refer to the sketch below.



132. The base plate grout was left out during construction. The tension (kips) in a <u>single</u> anchor bolt at the bottom of the base plate due to the overturning force "P" as shown on the given sketch is most nearly:

    a. 12.1
    b. 14.2
    c. 15.0
    d. 28.3

For **Question 133**, refer to the diagram below.



Indicates Direction of
One-Way Conc. Slab on
Metal Form Deck

R = 0.08 (A−150) Where

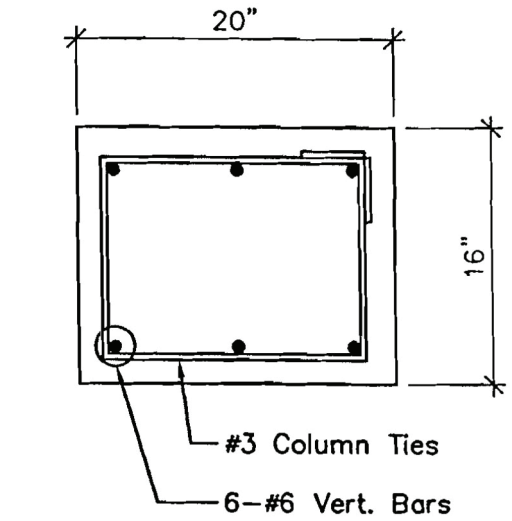
R = Reduction in Percentage

A = Area of Floor Supported by Girder G1 (Sq. Ft.)

133. Using the given floor plan and live load reduction formula, the live load reduction factor R (%) for girder G1 is most nearly:

a. 7
b. 9
c. 11
d. 16

For **Question 134**, refer to the section below.

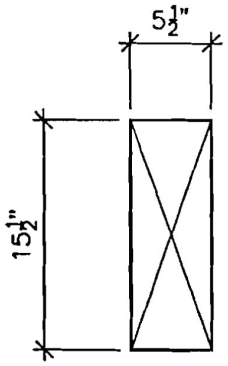


Conc. Column Section

134. Using the given concrete column section, the minimum required tie spacing (inches) is most nearly:

a. 18
b. 16
c. 12
d. 8

For **Questions 135**, refer to figure below.



Wood Beam Section

Given Information:

Wood beam is oriented such that loads are applied in the direction of the beams strong axis

Wood beam is in conditioned environment

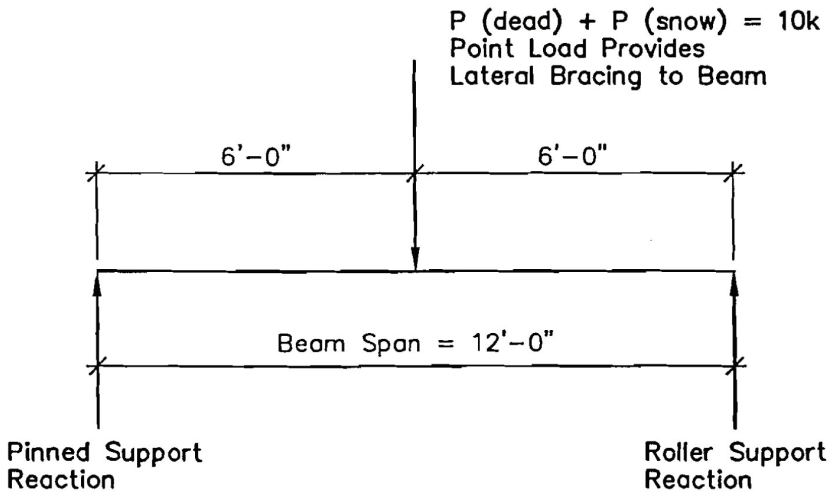
Visually graded lumber

Wood beam is seasoned lumber

F_b = 1,300 psi

F_v = 140 psi

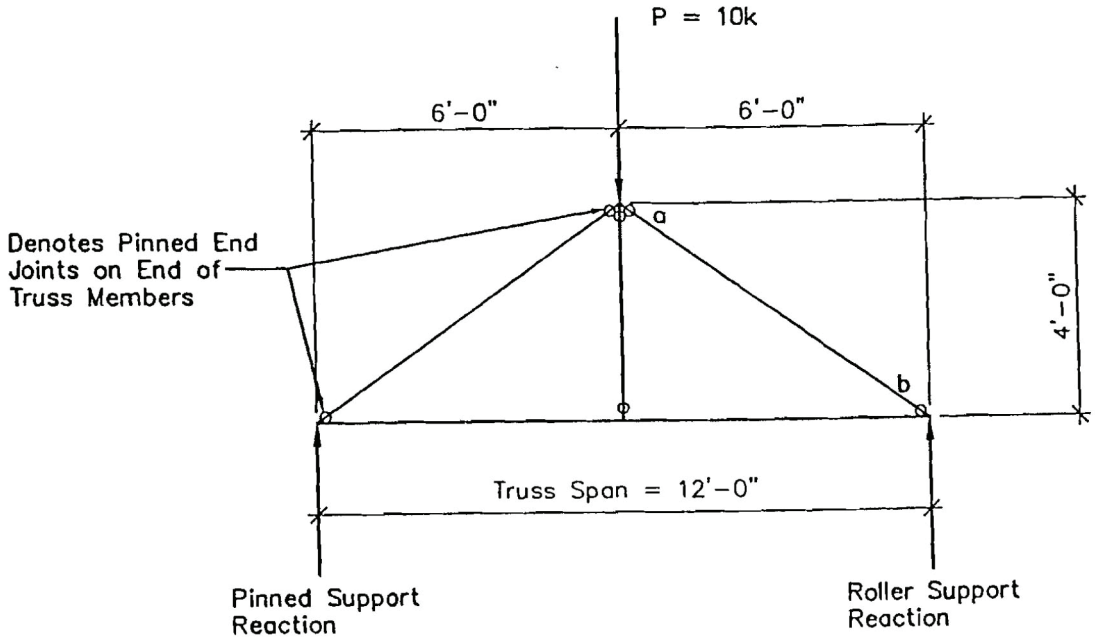
E = 1,500,000 psi



135. Using the information given, if the shear to be resisted by the wood beam section shown is 5 kips, the ratio of actual shear stress to the allowable shear stress is most nearly:

a. .37
b. .42
c. .55
d. .63

For **Questions 136**, refer to the truss geometry and load conditions below.



Steel Truss Diagram

136. Using the given truss geometry and load conditions in the steel truss diagram, the force (kips) in member a—b of the truss is most nearly:

    a. 5.0
    b. 6.0
    c. 7.5
    d. 9.0

137. Which of the following structural materials provides the greatest resistance to fire while maintaining its structural integrity?

    a. Structural steel
    b. Light wood framing
    c. Normal weight concrete
    d. Lightweight concrete

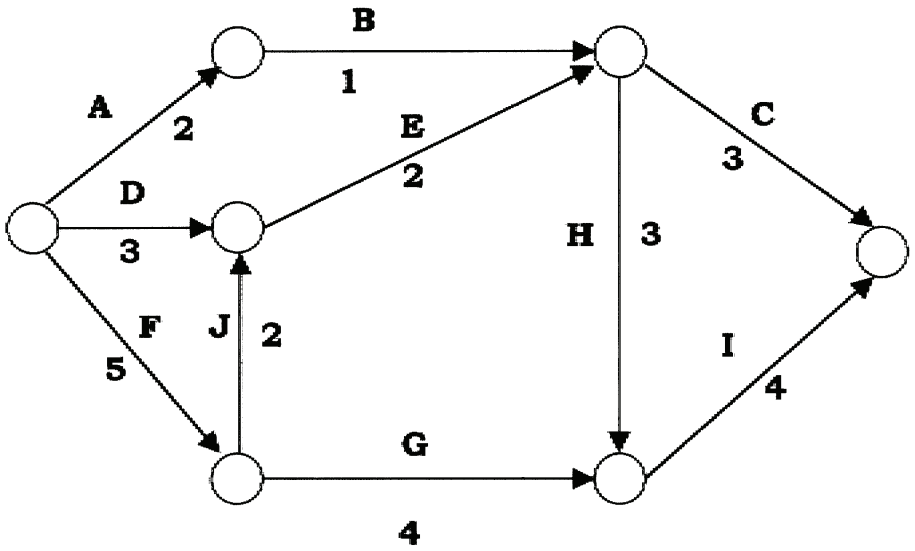
138. In a construction contract utilizing an AIA/A201 form of general conditions, a Construction Change Directive (CCD) has been issued to the Contractor. Issuance of the CCD directs the Contractor to proceed with the work in which of the following ways:

    a. Proceed on a time and material basis.
    b. Proceed and establish the final price of the change.
    c. Proceed and establish a time and a method to finalize the price.
    d. Proceed once a price has been finalized.

139. A construction contract is issued to a general contractor under an AIA/A201 form of contract. During the course of construction the architect believes that some of the work installed is in non-compliance with the technical specifications of the project. The architect directs the contractor to remove a portion of the work to expose the work in question, to determine if the hidden work was in compliance with the specifications. The work exposed is found to be in non-compliance. The architect has the financial responsibility for:

    a. the reinstallation cost of the work covering the non-complying work.
    b. the removal cost of the work covering the non-complying work.
    c. any testing and inspection cost to find if the work was in non-compliance.
    d. none of the costs associated with the removal, testing, or reinstallation.

For **Question 140**, refer to the diagram below.



140. Using the given schedule diagram, the total float in the path denoted by activities A — B — C is:

a. 4
b. 6
c. 7
d. 10

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Solutions for Sample Questions for the Morning Portion of the Examination in Architectural Engineering

Test Items 101-140

101. Stair pressurization fans, exit lights, egress corridor lighting.

Correct Answer is: b

102. The location of outside air intakes for the HVAC system.

Correct Answer is: d

103. Pressurize the elevator shafts and exit stairways.

Correct Answer is: a

104. The placement of the vapor barrier is critical in hot and humid climates and should be located on the outside face of the insulation and sheathing. A vapor barrier is best located where it can keep the most humid air out of most of the wall for most of the year.

Correct Answer is: b

105. In the original operating mode, the fan consumes:

40 kW x 2,080 hours x 0.08 = $6,656.00

Using the fan laws:

$W_1 = W_2 \times (Q_1/Q_2)^3 = 40 \times \left(\frac{20{,}000}{35{,}000}\right)^3 = 7.46$ kW

The new annual operating cost is: 7.46 x 2,080 x 0.08 = $1,241.00

The annual savings = $6,656.00 - $1,241.00 = $5,417.00

Say $5,420.00

Correct Answer is:b

106. 5/8” gypsum board sheathing each side of wall resiliently attached to CMU wall adds plus 15 points to STC rating.

Correct Answer is: d

107. Police station, Occupancy Category IV, Importance Factor I = 1.5
With all other factors being the same, the largest importance factor would cause the largest calculated seismic force.

Correct Answer is: d

108. Luminance Factor

Correct Answer is:c

109. $V = IZ$ $\qquad I_{LN} = \frac{V_{LN}}{Z_L} = \frac{120\angle 0°}{2\angle 40°} = 60\angle -40°$

Correct Answer is: b

110. (1.25 × 9.8) + (7.2) + (5.8) = 25.3 A

Correct Answer is: b

111.

Lighting	50 + 40 + 45 = 135 kVA x 100%	=135.0 kVA
Receptacles	10 + 20 + 15 = 45 kVA, (45-10) x .50 + 10	= 27.5 kVA
Other Cont. Loads	20 + 25 + 25 = 70 kVA x 100%	= 70.0 kVA
		232.5 kVA

Correct Answer is: a

112. FLA $\frac{1500}{\sqrt{3}\times 0.48}$ = 1,804 = kVA (3 phase)/SQRT (3) $\times$ KV (L-Lsec)

FLA = 1804A

Correct Answer is: d

113. $\text{I average} = \frac{261 + (2 \times 244) + (2 \times 255) + (2 \times 365) + 442}{8} = 303.9$

Zonal Constant = 2 x 3.14159 (cos 70 - cos 80) = 1.058

Zonal Lumens = I average x zonal constant = 303.9 x 1.058 = 321.5 Correct Answer is: b

114. $\frac{746\ W}{HP} \times \frac{10\ HP}{.90} = \frac{746 \times 10}{.9 \times .85} = 9752\ VA$

$4 \times 9752 = 39{,}008$ VA

Theta = cos -1 (.85) = 31.79°

1. kW = 4 x 8.289 = 33.16 kW
   kVAR = 39,008 × Sin 31.79 = 20.55 kVAR (Lag)
   Theta = cos -1 (.92) = 23.07°
2. kW = 80 x cos 23.07 = 73.60 kW
   kVAR = 80 x sin 23.07 = 31.35 kVAR (Lag)
3. kW = 3 x 10 = 30 kW
   kVAR = 0

Sum kW = 33.16 + 73.60 + 30 = 136.76 kW

Theta = cos - 1 (.98) = 11.48°

kVAR@ .98 = 136.76 kW × tan 11.48 = 27.77 kVAR

CAP kVAR = [(20.55 + 31.35) - 27.77] = 24.13 (Leading)

Correct Answer is: b

115. Vector Diagram B

Correct Answer is:b

116. For rigid metal conduit, there shall be not more than the equivalent of four quarter bends between pull points and there shall be not more than 360 degree in bends between pull points.

Correct Answer is: a, I and IV only

117. pcc =70% pw =50% pfc = 20% hrc = 8 - 2.5 = 5.5 feet

$$RCR = \frac{5 \times 55 \times (14 + 28)}{14 \times 28} = 2.95 = 3 \quad CU = .59$$

$$\text{Number of Luminaries} = \frac{75 \times (14 \times 28)}{3 \times 2900 \times 59 \times .70 \times .86 \times .88 \times 1.0} = 10.8$$

11 Luminaries required

Correct Answer is: a

118. Plumbing vents should be sloped to drain back to soil or waste pipe by gravity, at any amount of slope.

Correct Answer is: b

119. Variable frequency drive on the condenser pump.

Correct Answer is: a

120. Using the sensible heat equation

162,000 BTU/hr. = 1.08 x CFM x (30)

CFM =5,000

Correct Answer is: b

121. Q condenser = (0.70) (.75 × 600 tons) (3,413 BTU/kW - hr) + (.75 × 600 tons)

(12,000 BTU/hr - ton) = 6,475,095 BTU/hr

Correct Answer is: c

122. The best way to save energy on the cooling tower fan at part load is achieved by controlling fan speed from cooling tower leaving water temperature.

Correct Answer is: b

123. The area of roof which drains to the vertical riser Section A = 100 x 75 = 7,500 square feet. Using Table 2, for a 5 inch/hour rainfall with 7,500 square feet roof area per vertical riser, a 6 inch vertical riser is required.

A 6 inch vertical riser can accommodate 10,800 square feet.

Correct Answer is: d

124. Calculate R-value between studs

1/2 inch Siding			.75
Batt Insulation	5.5 × 4.0	=	22.0
1/2 inch Gyp Board	1/2.22	=	.45
			23.20

Calculate R-value at studs

1/2 inch Siding			.75
Wood Stud	5.5 × 1.0	=	5.5
1/2 inch Gyp Board	1/2.22	=	.45
			6.70

1 1/2 inch wide studs at 24 inches on center.

Wall with Batt Insulation = 22.5/24 = .9375

Wall with Wood Stud = 1.5/24 = .0625

$$U = \frac{1}{R} = .9375\left(\frac{1}{23.20}\right) + .0625\left(\frac{1}{6.70}\right) = 0.0497$$

$$say, 0.50$$

Correct Answer is: c

125. 135° F to 170° F

Correct Answer is: a

126. Using the Friction Loss Chart, 10,000 cfm in a 20 inch diameter duct = 4,500 fpm

Time velocity pressure is $(4,500/4,005)^2$ = 1.26 inches

The static pressure at Point A is 6.00 - 1.26 = 4.74 inches

Using the Friction Loss Chart, the pressure drop is 1.2 inches per 100 feet of duct, for a total drop of 3.6 inches.

The static pressure at Point B is 4.74 - 3.6 = 1.14 inches

1.14 inches of water gauge

Correct Answer is: a

127. Install a static pressure sensor two-thirds of the way down the main duct.

Correct Answer is: a

128. Concrete compressive strength

Correct Answer is: c

129. Moment resisting frame.

Correct Answer is: a

130. With a flexible roof diagram, loads are distributed to the resisting members based on tributary area.

The total lateral force to the center lateral frame is 200#/ft. x 30 feet = 6,000 pounds

The shear force in roof diagram each side of center lateral frame is 6,000/2 =3,000 pounds

The roof diaphragm force is $\frac{3{,}000 \text{ pounds}}{40 \text{ feet}}$ = 75 pounds/foot

Correct Answer is: b

131. Column looting axial load =100 K

Column footing overturning moment =50 k-ft.

Eccentricity = M/P = 50/100 = 0.5 foot

b/6 =7/6 =1.167 ft > e

$$q \max = P/A\left(1 \pm \frac{6e}{b}\right) = \frac{100}{7 \times 7}\left(1 \pm \frac{6 \times .5}{7}\right) = 2.04\left(1 \pm .43\right)$$

q max = 2.04 x 1.43 = 2.92 ksf

q min = 2.04 x .57 = 1.16 ksf

Correct Answer is: c

132. Calculate moment at bottom of base plate: 10k x 34 inches = 340 k-in

Distance between centerline of anchor bolts =12 inches

$$\text{Tension in one anchor bolt} = \frac{340}{12 \times 2} = 14.2 \text{ k}$$

Correct Answer is: b

133. Calculate the area of floor supported by Girder G1:

$$\frac{14}{2}(8 \times 3) + \left(\frac{16}{2} \times 8\right) + \left(\frac{16}{2} \times \frac{8}{2}\right) = 264 \text{ square feet}$$

R = 0.08 (264 -150) = 9.12 9%

Correct Answer is: b

134. Use the provisions of ACI 318, Section 7.10.5.2

Maximum Column Tie Spacing =16 db = 16 × .75 =12 inches

or

48 d tie = 48 × .375 = 18 inches

or

least column dimension = 16 inches

12 inch controls

Correct Answer is: c

135. Calculate actual shear stress

$$Fv = \frac{3V}{2A} = \frac{3 \times 5{,}000}{2 \times (5.5 \times 15.5)} = 88 \text{ psi}$$

Calculate allowable shear stress

$F'v = F_v \times C_D \times C_M \times C_t \times C_H$

Fv = 140psi C_D = 1.15

$C_t = C_H = 1.0$, C_M (Not Applicable)

F'v = 140 x 1.15 = 161 psi

$$\frac{88}{161} = .55$$

Correct Answer is: c

136. Support Reactions = 10K/2 = 5k

Length of member $a - b = \sqrt{4^2 + 6^2} = 7.21$ feet

$$\frac{\text{Force } a - b}{7.21 \text{ feet}} = \frac{5^k}{4 \text{ feet}}$$

$$\text{Force } a - b = \frac{5 \times 7.21}{4} = 9.0^k$$

or $\Sigma Fy = 0 = 5 - (Fa - b \sin 33.7)$

$$Fa - b = \frac{5}{\sin 33.7} = 9.0^k$$

Correct Answer is: d

137. Lightweight concrete

Correct Answer is:d

138. The CCD obligates the contractor to proceed with the work, and establishes a method and time to settle the final price. This way the settlement of the final price causes no negative impact on the project schedule.

Correct Answer is: c

139. None of the cost associated with the removal, testing, or reinstallation.

Correct Answer is: d

140. The critical path for the schedule diagram is 16 time units. The path is defined as F - J - E - H - I. The path A - B - C has a duration of 6 time units. The difference between the critical path and the defined path is 16 – 6 = 10 time units.

Correct Answer is: d

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Sample Questions for the Afternoon Portion of the Examination in Architectural Engineering

Test Items 501-540

501. A vapor retarder is to be installed below a building slab on grade floor. The primary reason to install a vapor retarder is:

    a. To minimize the loss of water from the concrete floor slab into the subgrade soils during the slab curing process
    b. To minimize the transmission of moisture vapor from the subgrade soils into the concrete floor slab
    c. To improve the slab curing process and to reduce the chance for curling of the slab edges and corners
    d. To reduce the bleed water period and speed up the slab finishing timeline

502. Highly sensitive equipment is to be placed on an elevated floor systems in a building. Which of the following locations would be the best choice to locate the equipment in an effort to minimize the impact of vibrations caused by walking by the building users.

    a. Adjacent to a building support column
    b. At the mid-span of the floor beams
    c. Directly adjacent to an interior corridor
    d. In a large open room with no partition walls

503. Walls are to be constructed around the perimeter of a mechanical room to limit the sound transmission from the mechanical room to the adjacent office areas. Considering only the wall materials, which of the following walls has a higher sound transmission class, STC:

    a. 6-inch thick CMU block wall
    b. 8-inch thick reinforced concrete wall
    c. 12-inch thick CMU block wall
    d. 6-inch thick CMU block wall plus 2-inch air space plus 6-inch thick CMU block wall

504. Natural stone is to be installed on the exterior facade of a building. The owner of the building wants to select a stone which has good properties regarding absorption to moisture and would thereby provide good resistance to frost action and repeated freeze-thaw cycles. Which of the following natural stones would be considered to be the best choice since it has the lowest absorption of moisture properties.

    a. Sandstone
    b. Limestone
    c. Quartzite sandstone
    d. Granite

505. A mechanical unit which weighs 5000 pounds is suspended from a floor system. Using the following Table 1.1 and Section 13.1 from the ASCE 7-05, which of the following building occupancy types would have the largest calculated seismic force from the mechanical unit which must be resisted by bracing?

    a. Church with a 2000 seat assembly area
    b. Hospital with emergency treatment facilities
    c. Water treatment facility
    d. 15,000 seat multi-use arena

Section 13.1 ASCE 7-05

13.1 GENERAL

13.1.1 Scope. This chapter establishes minimum design criteria for nonstructural components that are permanently attached to structures and for their supports and attachments.

13.1.2 Seismic Design Category. For the purposes of this chapter, nonstructural components shall be assigned to the same seismic design category as the structure that they occupy or to which they are attached.

13.1.3 Component Importance Factor. All components shall be assigned a component importance factor as indicated in this section. The component importance factor, I_p, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems.
2. The component contains hazardous materials.
3. The component is in or attached to an Occupancy Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.

All other components shall be assigned a component importance factor, I_p, equal to 1.0.

(continued)

Section 13.1 ASCE 7-05 *(continued)*

13.1.4 Exemptions. The following nonstructural components are exempt from the requirements of this section:

1. Architectural components in Seismic Design Category B other than parapets supported by bearing walls or shear walls provided that the component importance factor, I_p, is equal to 1.0.
2. Mechanical and electrical components in Seismic Design Category B.
3. Mechanical and electrical components in Seismic Design Category C provided that the component importance factor, I_p, is equal to 1.0.
4. Mechanical and electrical components in Seismic Design Categories D, E, and F where the component importance factor, I_p, is equal to 1.0 and either:
    a. Flexible connections between the components and associated ductwork, piping, and conduit are provided.
    b. Components are mounted at 4 ft (1.22 m) or less above a floor level and weigh 400 lb (1780 N) or less.
5. Mechanical and electrical components in Seismic Design Categories D, E, and F where the component importance factor, 1p, is equal to 1.0 and
    a. Flexible connections between the components and associated ductwork, piping, and conduit are provided.
    b. The components weigh 20 lb (89 N) or less or, for distribution systems. weighing 5 lb/ft (73 N/m) or less.

13.1.5 Applicability of Nonstructural Component Requirements. Where the weight of a nonstructural component is greater than or equal to 25 percent of the effective seismic weight, W, defined in Section 12.7.2, the component shall be classified as a nonbuilding structure and shall be designed in accordance with Section 15.3.2.

Nonbuilding structures (including storage racks and tanks) that are supported by other structures shall be designed in accordance with Chapter 15. Where Section 15.3 requires that seismic forces be determined in accordance with Chapter 13 and values for Rp are not provided in Table 13.5-1 or 13.6-1, Rp shall be taken as equal to the value of R listed in Section 15. The value of a^p shall be determined in accordance with footnote a of Table 13.5-1 or 13.6-1.

13.1.6 Reference Documents. Where a reference document provides a basis for the earthquake-resistant design of a particular type of system or component, that document is permitted to be used, subject to the approval of the authority having jurisdiction and the following conditions:

a. The design earthquake forces shall not be less than those determined in accordance with Section 13.3.1.
b. Each component's seismic interactions with all other connected components and with the supporting structure shall be accounted for in the design. The component shall accommodate drifts, deflections, and relative displacements determined in accordance with the applicable seismic requirements of this standard.

13.1.7 Reference Documents Using Allowable Stress Design. Where a reference document provides a basis for the earthquake-resistant design of a particular type of system or component, and the same reference document defines acceptance criteria in terms of allowable stresses rather than strengths, that reference document is permitted to be used. The allowable stress load combination shall consider dead, live, operating, and earthquake loads in addition to those in the reference document. The earthquake loads determined in accordance with Section 13.3.1 shall be multiplied by a factor of 0.7. The allowable stress design load combinations of Section 2.4 need not be used. The component or system shall also accommodate the relative displacements specified in Section 13.3.2.

Source: ASCE 7-05.

TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with daycare facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generating stations[a] • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

[a] Cogeneration power plants that do not supply power on the national grid shall be designated Occupancy Category II.

Source: ASCE 7-05.

506. A building is to be constructed in compliance with Type IV, Heavy Timber Construction Classification in accordance with the 2006 International Building Code. Using the following Section 602 and Table 602.4 from the 2006 IBC, which of the following would be an acceptable minimum wood column size to support an elevated floor system?

    a. 6 x 6 solid sawn timber
    b. 6 x 6 glued laminated timber
    c. 8 x 8 solid sawn timber
    d. 6 x 8 glued laminated timber

SECTION 602
CONSTRUCTION CLASSIFICATION

602.1 General. Buildings and structures erected or to be erected, altered or extended in height or area shall be classified in one of the five construction types defined in Sections 602.2 through 602.5. The building elements shall have a fire-resistance rating not less than that specified in Table 601 and exterior walls shall have a fire-resistance rating not less than that specified in Table 602.

602.1.1 Minimum requirements. A building or portion thereof shall not be required to conform to the details of a type of construction higher than that type, which meets the minimum requirements based on occupancy even though certain features of such a building actually conform to a higher type of construction.

602.2 Types I and II. Type I and H construction are those types of construction in which the building elements listed in Table 601 are of noncombustible materials, except as permitted in Section 603 and elsewhere in this code.

602.3 Type III. Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code. Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less.

602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section. Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a 2-hour rating or less. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued-laminated members the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4.

602.4.1 Columns. Wood columns shall be sawn or glued laminated and shall not be less than 8 inches (203 mm), nominal, in any dimension where supporting floor loads and not less than 6 inches (152 mm) nominal in width and not less than 8 inches (203 mm) nominal in depth where supporting roof and ceiling loads only. Columns shall be continuous or superimposed and connected in an approved manner.

602.4.2 Floor framing. Wood beams and girders shall be of sawn or glued-laminated timber and shall be not less than 6 inches (152 mm) nominal in width and not less than 10 inches (254 mm) nominal in depth. Framed sawn or glued-laminated timber arches, which spring from the floor line and support floor loads, shall be not less than 8 inches (203 mm) nominal in any dimension. Framed timber trusses supporting floor loads shall have members of not less than 8 inches (203 mm) nominal in any dimension.

602.4.3 Roof framing. Wood-frame or glued-laminated arches for roof construction, which spring from the floor line or from grade and do not support floor loads, shall have members not less than 6 inches (152 mm) nominal in width and have less than 8 inches (203 mm) nominal in depth for the lower half of the height and not less than 6 inches (152 mm) nominal in depth for the upper half. Framed or glued-laminated arches for roof construction that spring from the top of walls or wall abutments, framed timber trusses and other roof framing, which do not support floor loads, shall have members not less than 4 inches (102 mm) nominal in width and not less than 6 inches (152 mm) nominal in depth. Spaced members shall be permitted to be composed of two or more pieces not less than 3 inches (76 mm) nominal in thickness where blocked solidly throughout their intervening spaces or where spaces are tightly closed by a continuous wood cover plate of not less than 2 inches (51 mm) nominal in thickness secured to the underside of the members. Splice plates shall be not less than 3 inches (76 mm) nominal in thickness. Where protected by approved automatic sprinklers under the roof deck, framing members shall be not less than 3 inches (76 mm) nominal in width.

(continued)

SECTION 602 — CONSTRUCTION CLASSIFICATION *(continued)*

602.4.4 Floors. Floors shall be without concealed spaces. Wood floors shall be of sawn or glued-laminated planks, splined or tongue-and-groove, of not less than 3 inches (76 mm) nominal in thickness covered with 1-inch (25 mm) nominal dimension tongue-and-groove flooring, laid cross-wise or diagonally, or 0.5-inch (12.7 mm) particleboard or planks not less than 4 inches (102 mm) nominal in width set on edge close together and well spiked and covered with 1-inch (25 mm) nominal dimension flooring or 15/32-inch (12 mm) wood structural panel or 0.5-inch (12.7 mm) particleboard. The lumber shall be laid so that no continuous line of joints will occur except at points of support. Floors shall not extend closer than 0.5 inch (12.7 mm) to walls. Such 0.5-inch (12.7 mm) space shall be covered by a molding fastened to the wall and so arranged that it will not obstruct the swelling or shrinkage movements of the floor. Corbeling of masonry walls under the floor shall be permitted to be used in place of molding.

602.4.5 Roofs. Roofs shall be without concealed spaces and wood roof decks shall be sawn or glued laminated, splined or tongue-and-groove plank, not less than 2 inches (51 nun) nominal in thickness, 11/8-inch-thick (32 mm) wood structural panel (exterior glue), or of planks not less than 3 inches (76 mm) nominal in width, set on edge close together and laid as required for floors. Other types of decking shall be permitted to be used if providing equivalent fire resistance and structural properties.

602.4.6 Partitions. Partitions shall be of solid wood construction formed by not less than two layers of 1-inch (25 mm) matched boards or laminated construction 4 inches (102 mm) thick, or of 1-hour fire-resistance-rated construction.

602.4.7 Exterior structural members. Where a horizontal separation of 20 feet (6096 mm) or more is provided, wood columns and arches conforming to heavy timber sizes shall be permitted to be used externally.

602.5 Type V. Type V construction is that type of construction in which the structural elements, exterior walls and interior walls are of any materials permitted by this code.

Source: 2006 International Building Code. Reprinted by permission of the International Code Council, www.iccsafe.org.

TABLE 602.4
WOOD MEMBER SIZE

MINIMUM NOMINAL SOLID SAWN SIZE		MINIMUM GLUED-LAMINATED NET SIZE	
Width, inch	Depth, inch	Width, inch	Depth, inch
8	8	$6\,^3/_4$	$8^1/_4$
6	10	5	$10^1/_2$
6	8	5	$8^1/_4$
6	6	5	6
4	6	3	$6\,^7/_8$

For SI: 1 inch = 25.4 mm.

Source: 2006 International Building Code. Reprinted by permission of the International Code Council, www.iccsafe.org.

507. Reciprocating equipment is suspended from an elevated floor structure which induces vibrations into the floor system. Which of the following options would provide the best results in reducing the vibrations felt by the building users.

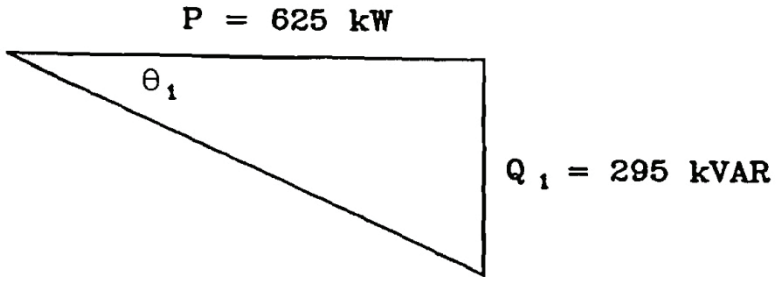
a. Increase the span of the floor framing members
b. Reduce the stiffness of the floor framing members
c. Increase the thickness of the floor slab supported by the floor framing members
d. Reduce the partition and ceiling loads applied to the floor framing members

508. A 208-volt, 3-phase, 4-wire, 600-ampere continuous linear load is to be fed through a transformer from an existing 480-volt, 3-phase, 4-wire switchboard.

Using the given information about this installation, the minimum standard size transformer (kVA) that can be used to serve this load is most nearly: (Assume the transformer is 100% rated.)

a. 150
b. 225
c. 300
d. 500

For **Question 509**, refer to the following diagram.



509. For the power triangle shown in the given diagram, the amount of capacitance in kVAR that must be added to bring the power factor to .95 is most nearly:

a. 90
b. 205
c. 295
d. 691

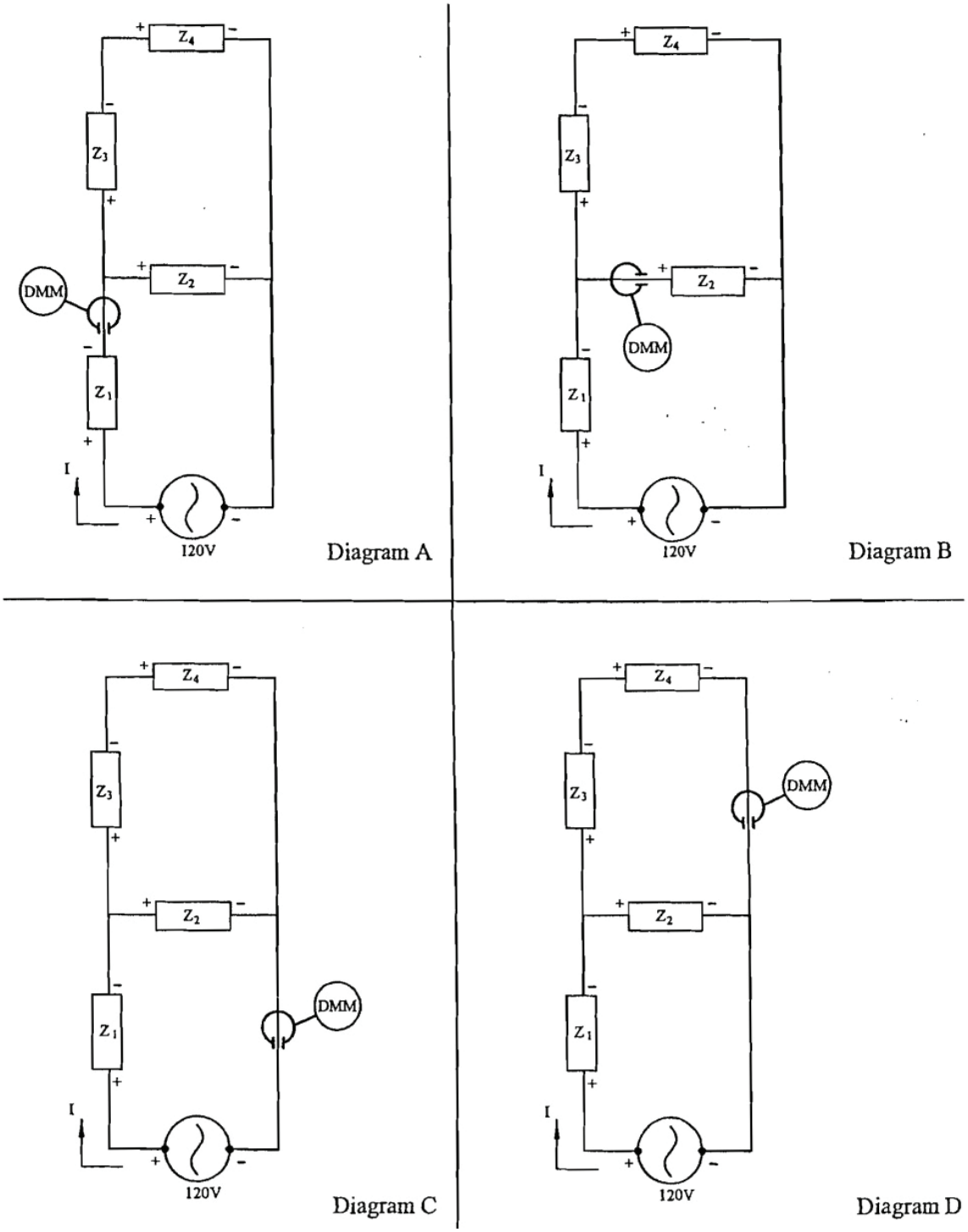
510. A factory has the following loads:

1. 60 kilowatts of resistance heating
2. 100 kilowatts at a Lagging Power Factor = 0.707
3. 40 kilowatts of Leading Power Factor = 0.80

The total kVA and the overall power factor for these loads is most nearly:

a. 203.7 kVA @ .982 Lagging
b. 203.7 kVA @ .982 Leading
c. 211.9 kVA @ .944 Lagging
d. 211.9 kVA @ .944 Leading

For **Question 511**, refer to the following diagrams.



511. Using the given diagrams, the correct location of a clamp-on digital multimeter (DMM) to measure the current flowing in load $\mathbf{Z_2}$ is shown in?

e. Diagram A
f. Diagram B
g. Diagram C
h. Diagram D

For **Question 512**, refer to the following information.

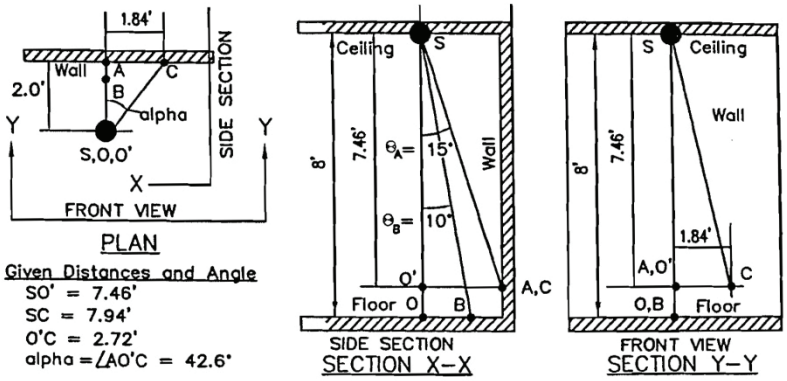
Lamp	Input Volts	Ballast Type	Input Watts	Input Current	Open Ckt. Voltage
H37LC-250/C	120	HX-NPF	285	4.80	240

512. A convenience store owner in a rural area is purchasing mercury vapor “yard” lights as security lighting around the property. The equipment supplier has provided the given operating data for the ballast. The MAXIMUM number of luminaires (yard lights), according to the NEC, that can be put on a 20A1P circuit breaker is most nearly:

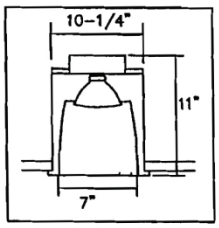
a. 8
b. 6
c. 3
d. 2

For **Question 513**, refer to the following Room Geometry and Photometric Data.

ROOM B— GEOMETRY:



PHOTOMETRIC DATA

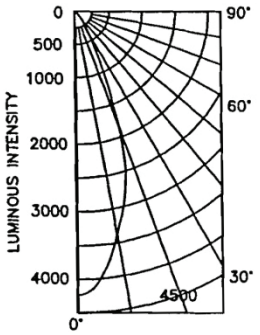


Luminaire –"BAE150B"

DESCRIPTION:
7" Recessed Incandescent
Downlight with Clear
Low Brightness Cone

LAMP: 150PAR38/FL VOLTS 120
LUMEN/LAMP 1740 DATE 1993
SHIELDING ANGLE: N 40 L 40
BARE 38000 FILE 100–R3
TEST NO. 72703 BY: RNH

CATEGORY IV



Luminaire Spacing Criterion = .60

LUMINOUS INTENSITY

θ	I
5	3987
10	3387
15	2786
20	1881
25	974
30	524
35	74
40	65
45	55
50	0
55	0

513. Using the given Room Geometry and Photometric Data, the illuminance level, (fc), E_A, at point "A" on the vertical surface from the source S, is most nearly:

a. 12.1
b. 13.0
c. 45.2
d. 48.4

514. The utility serving the building you are designing the power distribution tells you that the available fault current at the service entrance is 22 MVA at 480 volts. The minimum allowable interrupting rating (A) of the main circuit breaker at your service entrance that meets the requirements of the National Electrical Code is most nearly: The ratings (A) listed below are “standard” interrupting ratings.

    a. 22,000
    a. 42,000
    b. 65,000
    c. 100,000

515. In constructing a Single Phase, Series Vector Diagram, which one of the following statements is true?

    a. The reference axis is always drawn vertical.
    b. The resistive component and reference axis are always “out of phase.”
    c. The phase relationship between vector components is always counter clockwise.
    d. The phase relationship between the impedance and the reference axis is always 90 degrees.

516. A motor is a 3-phase 460 V NEMA Design B induction motor. During testing, the maximum locked rotor current of the motor measures as 290 Amperes, and the full-load current measures as 52 Amperes. The rated horsepower of this motor is expected to be most nearly:

    a. 25
    b. 30
    c. 40
    d. 45

517. A motor is rated at 100 HP, 460 volts, 60 Hz, and draws 120 amps of current at full load. If the motor has an efficiency of 92%, the motor’s power factor if most nearly:

    a. 0.75
    b. 0.80
    c. 0.85
    d. 0.90

518. A 6-inch pump operating at 1,800 rpm discharges 1,800 gpm of cold water (S.G. =1) against an 80 foot head at 60% efficiency. A dynamically similar 8-inch pump operating at 1,170 rpm is considered as a replacement. The total head (ft.) that can be expected from the new pump is most nearly:

    a. 52.00
    b. 60.09
    c. 106.15
    d. 106.66

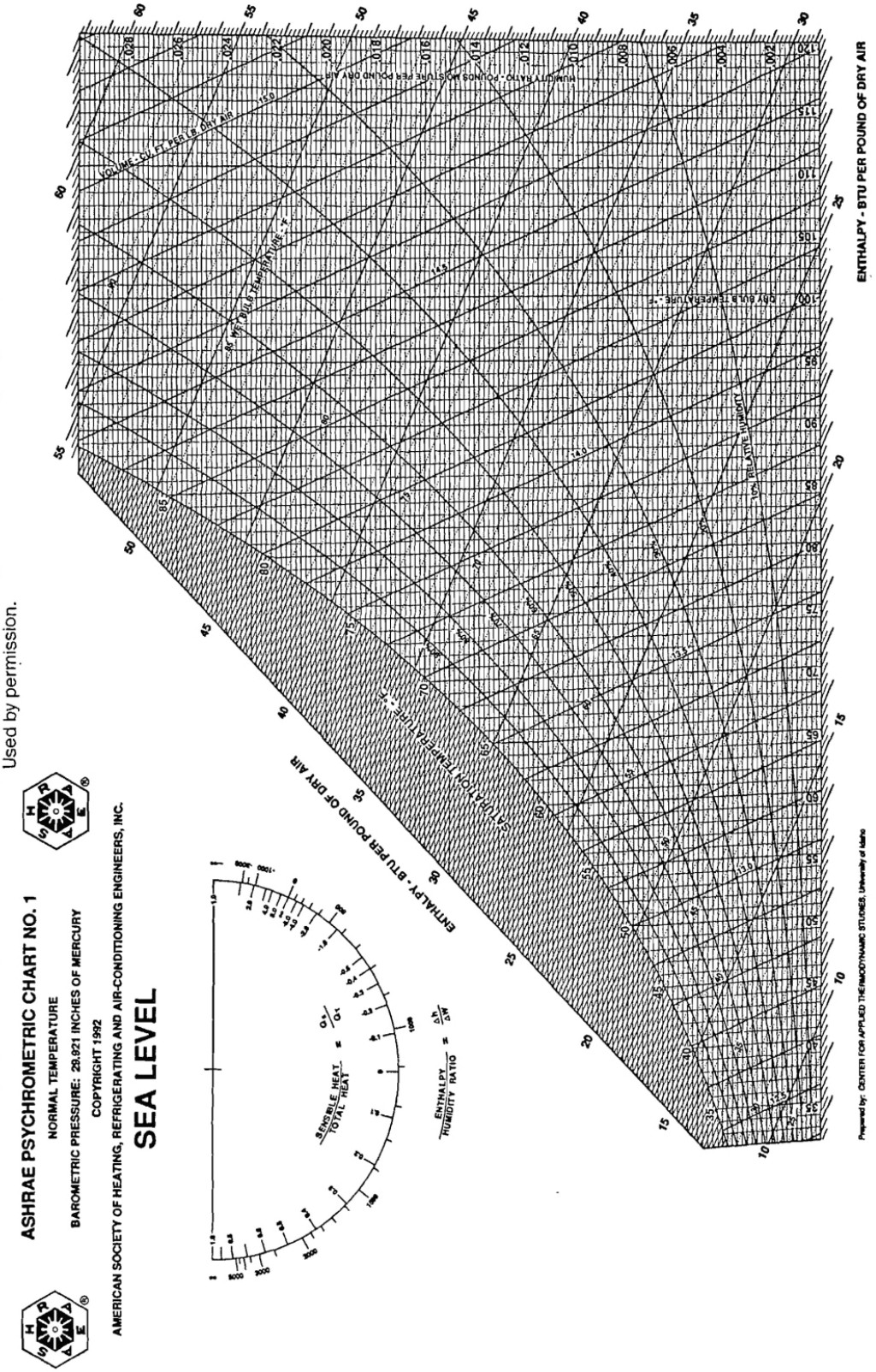
519. According to the requirements of NFPA 13-2007, the maximum floor area (ft^2) on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser for ordinary hazard occupancy should be most nearly:

    a. 25,000
    b. 52,000
    c. 60,000
    d. Unlimited floor area

520. With a chilled water and hot water primary system, which of the following air distribution systems delivers supply air from the air handling unit at a constant temperature during summertime operation:

    a. A system consisting of fan-coil units.
    b. A system consisting of single zone air handling units.
    c. A system consisting of variable air volume (VAV) air handling units.
    d. A system consisting of multizone air handling units.

For **Question 521**, use the following psychrometric chart.



521. An air handling unit circulates a total of 20,000 CFM, of which 2,000 CFM is outside air. Given a return air condition of 80 degrees F, 60% RH and an outside air condition of 95 degrees F, 50% RH, the mixed air condition (degrees F, % RH) is most nearly:

    a. 93.6 degrees F and 51% RH
    b. 87.5 degrees F and 56% RH
    c. 85.0 degrees F and 56% RH
    d. 81.4 degrees F and 59% RH

522. For which of the flowing systems must the elevation head be taken into consideration when selecting a pump?

    a. A condenser loop for an open cooling tower.
    b. A chilled water pump for an HVAC system.
    c. A hot water pump for a hydronic heating system.
    d. A domestic hot water re-circulation pump.

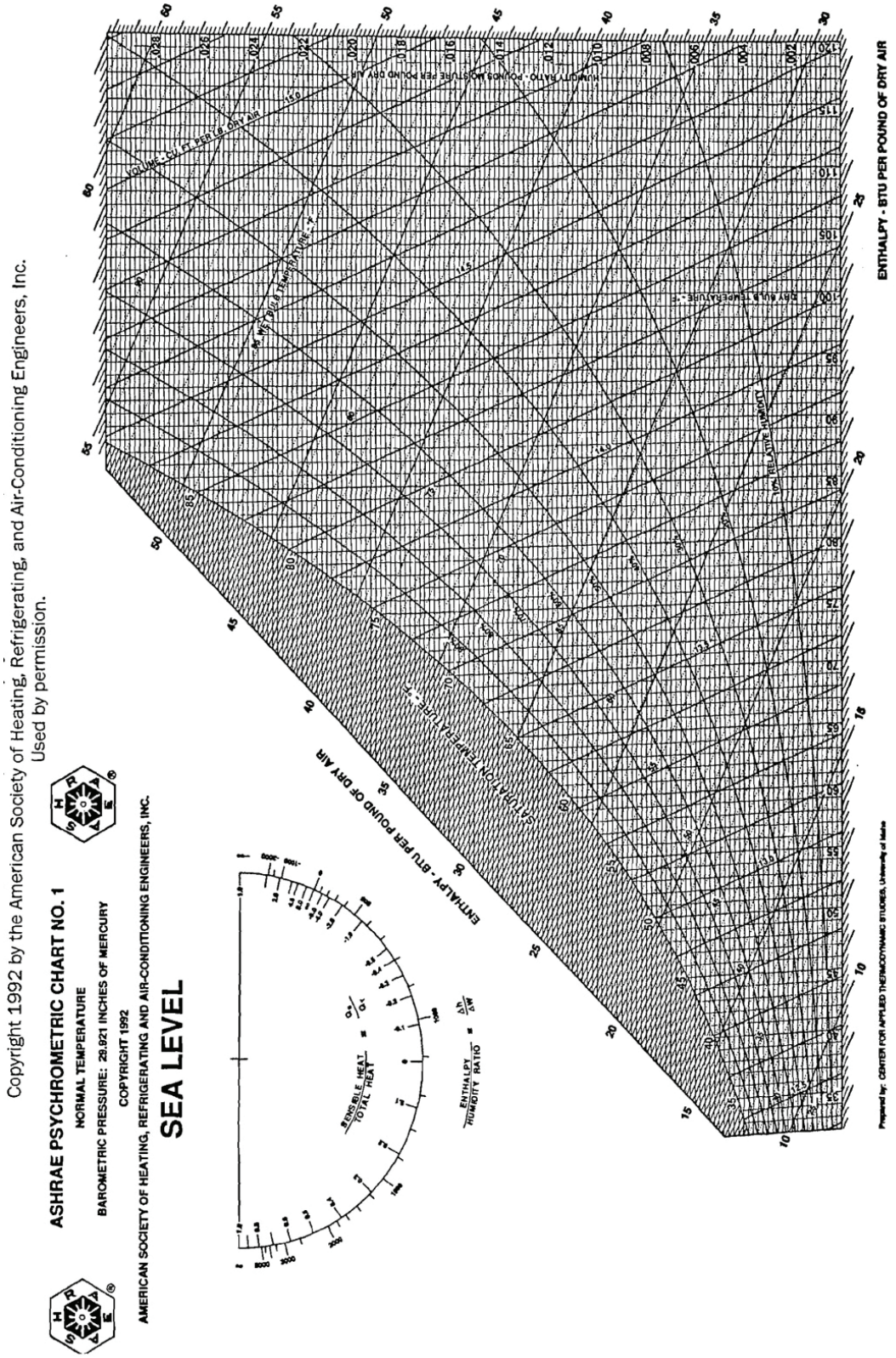
523. A condensing unit contains:

    a. Condenser fan, condenser coil, and compressor
    b. Condenser fan and condenser coil
    c. Evaporative condenser fan and condenser coil
    d. Condenser fan, condenser coil, compressor, evaporator fan, and evaporator coil

524. Two identical centrifugal pumps are operating in parallel and serving a single distribution loop. Which of the following will occur if one of the pumps is de-energized?

    a. The total flow in the distribution loop will decrease by more than 50% because the pump will “ride the curve.”
    b. The total flow in the distribution loop will decrease by 50% because the two installed pumps are identical and one is no longer operating.
    c. The total flow in the distribution loop will decrease by less than 50% as predicted by the intersection of the system curve and the simple pump curve.
    d. The total flow in the distribution loop will remain constant because the friction in the loop will be reduced by half.

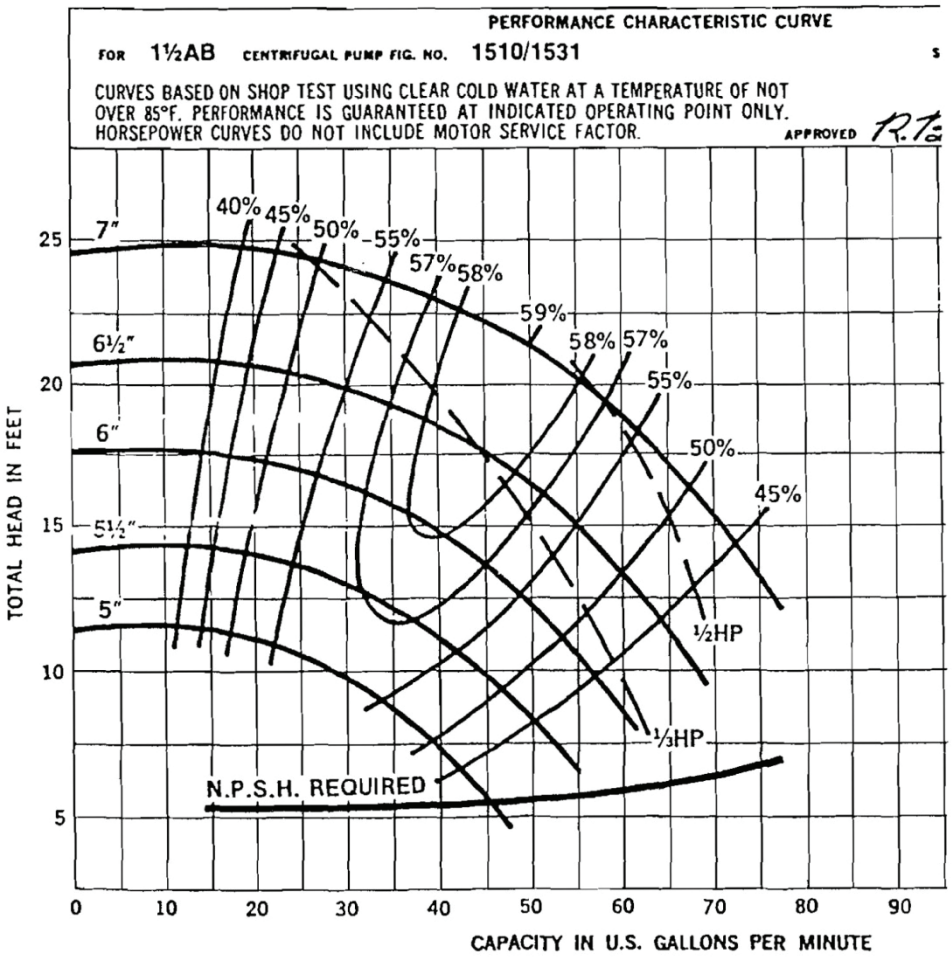
For **Question 525**, use the following psychrometric chart.



525. The entering and leaving air conditions for a 5,000 cfm cooling coil are: 80 degrees F, 60%RH, and 55 degrees F, 95%RH. Assuming a 10 degrees F temperature difference across the coil, the volume of chilled water (gpm) that must be supplied to the coil to satisfy these conditions is most nearly:

a. 12
b. 50
c. 105
d. 250

For **Question 526**, refer to the following performance curve.



Used by permission of Bell and Gossett.

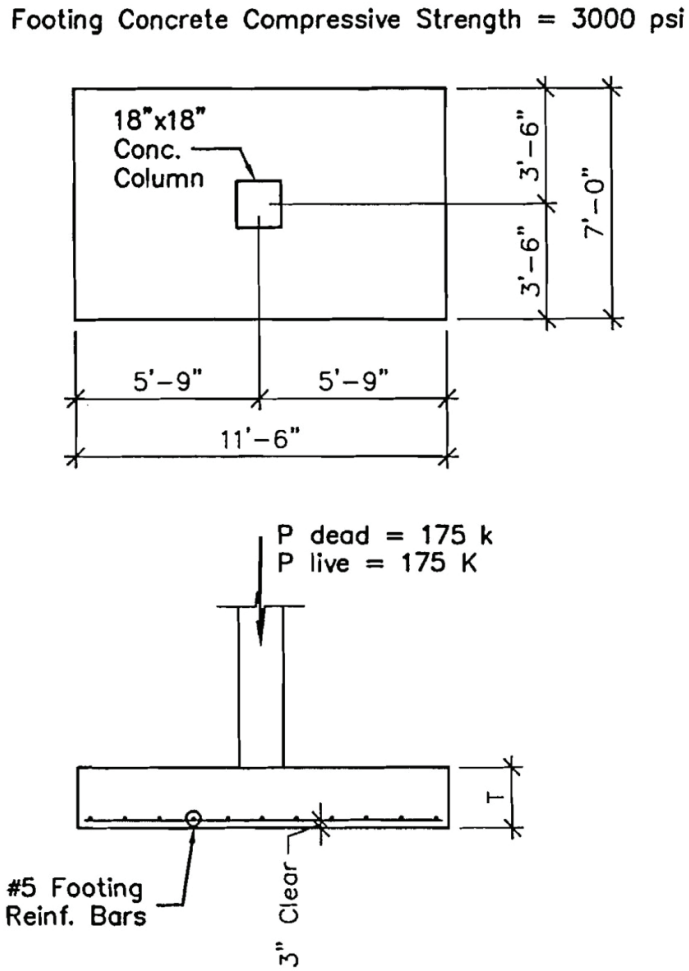
526. Using the given performance curve, 17.5 feet of head could be achieved with a flow rate of 45 GPM and a motor of 1/3 HP. If the 17.5 feet of head is constant, the flow rate (gpm) that could be achieved if the motor horsepower was increased to 1/2 HP is most nearly: (Assume no change in impeller size or RPM.)

a. 45
b. 55
c. 65
d. 70

527. For a centrifugal pump, the required net positive suction head [NPSHR] will:

a. Decrease with increased water flows
b. Remain constant with increased water flows
c. Increase with increased water flows
d. Be unaffected by increased water flows

For **Question 528**, refer to the following sketch.



528. Using the given column footing and column loading, the minimum thickness (inches) of the column footing to resist punching shear is most nearly:

a. 20
b. 24
c. 32
d. 35

For **Question 529**, refer to the following figures.

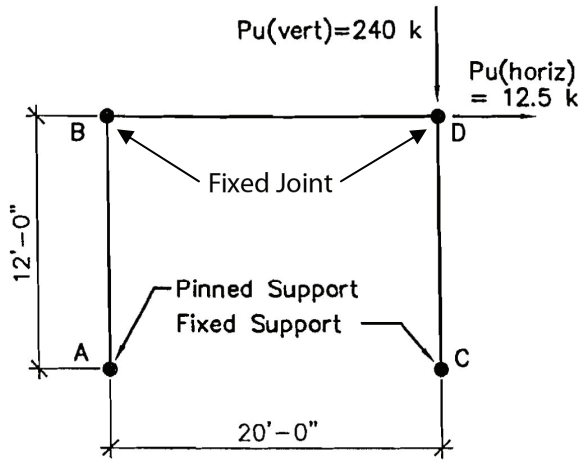
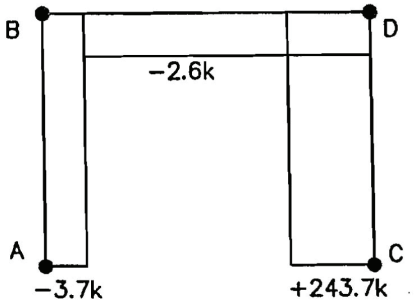
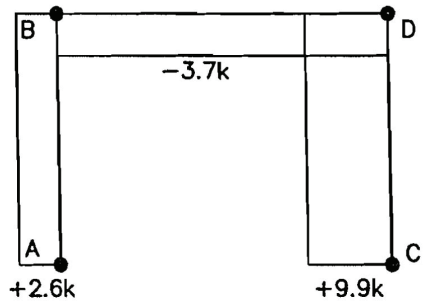


Figure 1



Axial Load Diagram

Figure 2



Shear Diagram

Figure 3

529. Given a rigid frame and factored loading as shown on Figure 1, the axial load diagram for the rigid frame as shown on Figure 2, and the shear diagram for the rigid frame as shown on Figure 3, the most probable moment diagram of the following moment diagrams is most nearly:

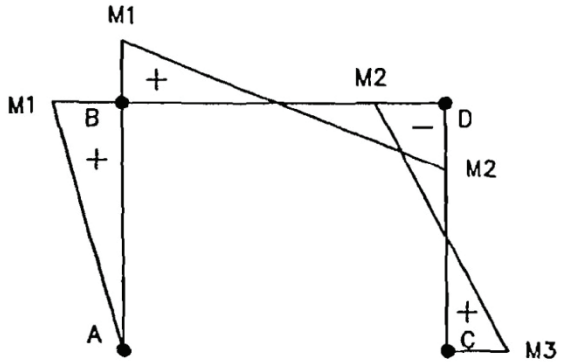


Diagram A

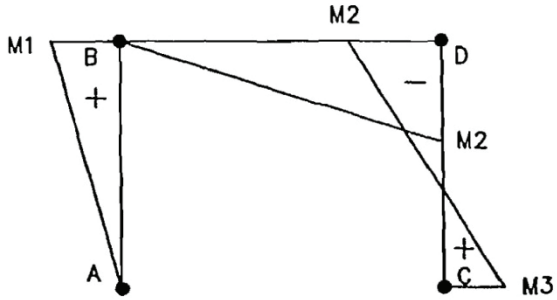


Diagram B

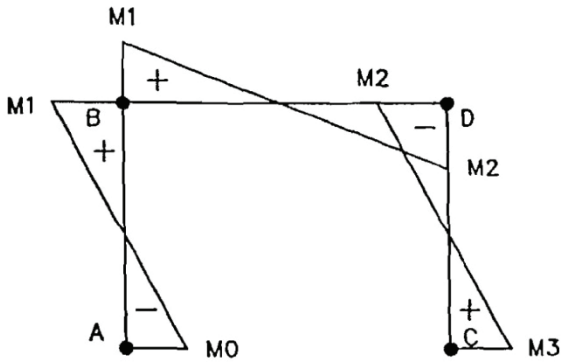


Diagram C

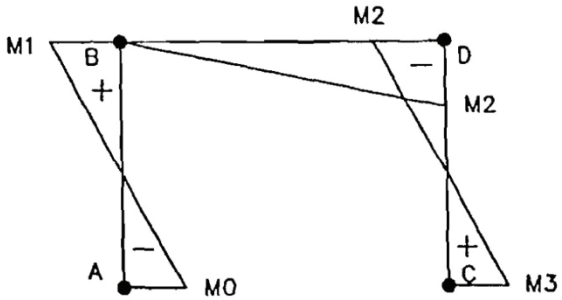


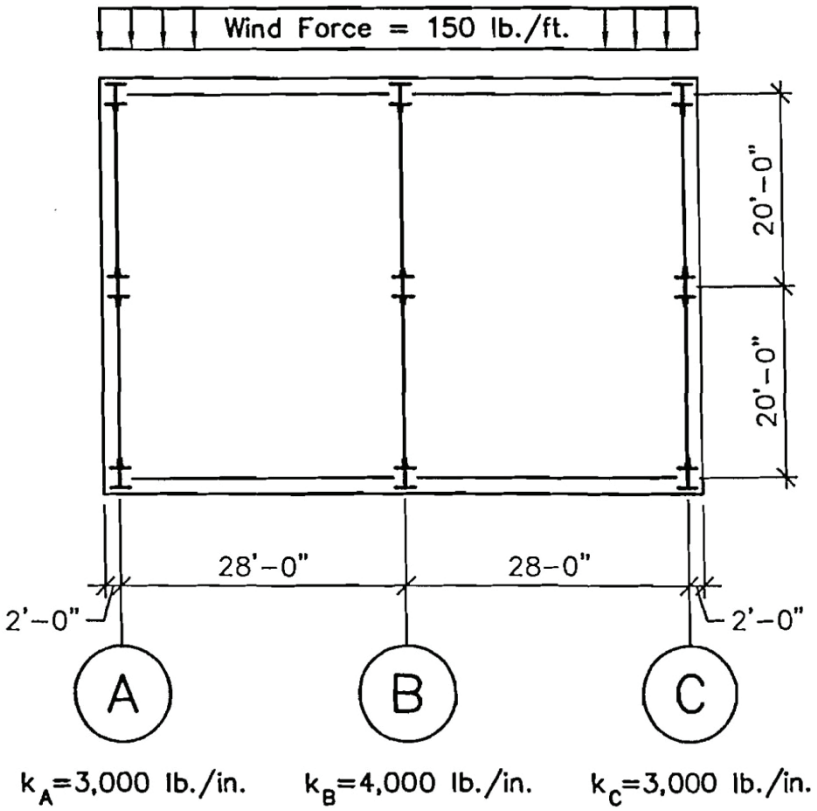
Diagram D

a. Diagram A
b. Diagram B
c. Diagram C
d. Diagram D

530. The minimum length (inches) of a 1/4 inch E70xx electrode fillet weld required to support a dead plus live load of 20 kips is most nearly:

a. 1.1
b. 1.6
c. 3.8
d. 5.4

For **Question 531**, refer to the following roof framing plan.



531. Using the given roof framing plan, wind force loading at the roof level, and stiffness of each frame, the maximum required capacity of the rigid diaphragm (lb./ft.) is most nearly:

a. 60
b. 63
c. 68
d. 90

For **Questions 532-533**, refer to the following subsurface soil condition and geotechnical properties.

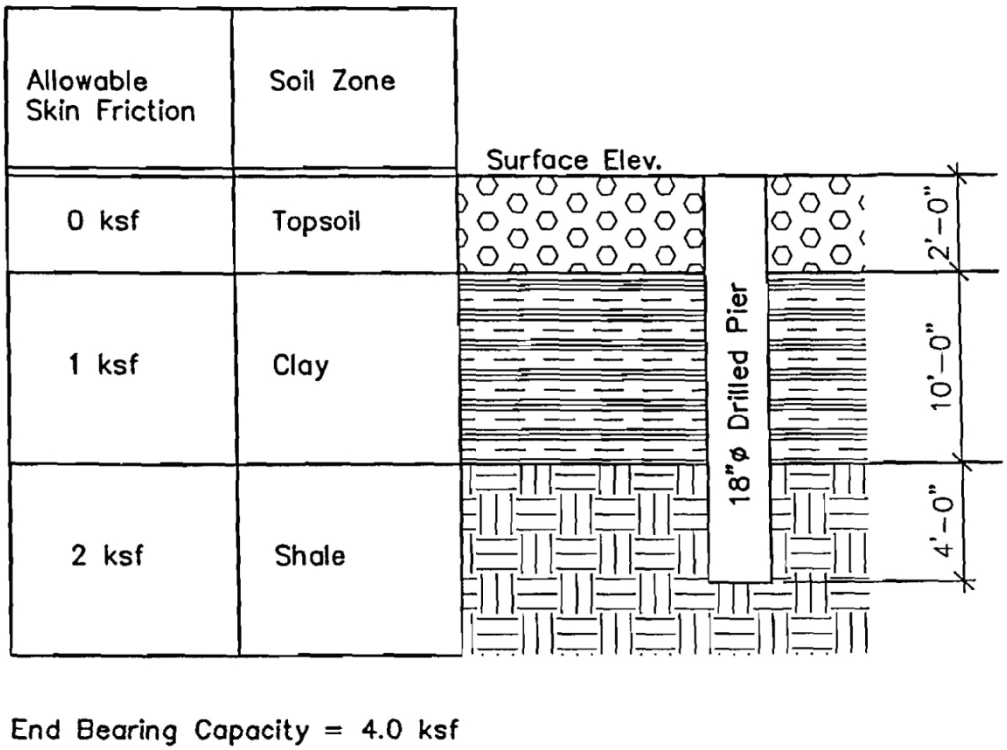


Figure 1

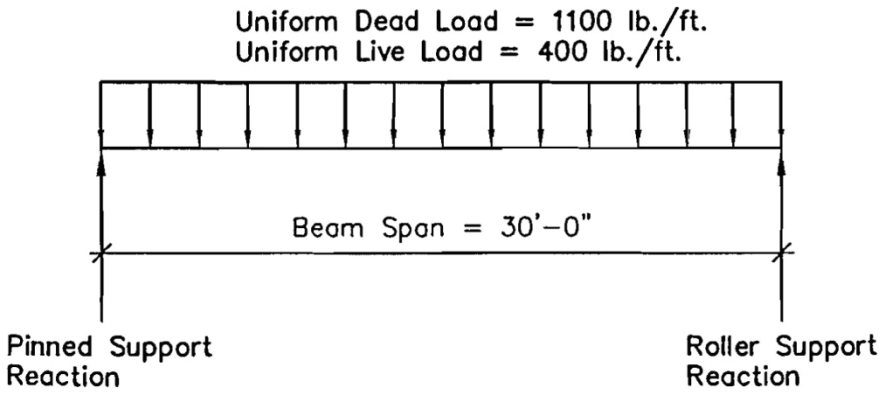
532. Using the given subsurface soil conditions and geotechnical properties shown in Figure 1, the maximum allowable capacity (kips) of the 18" diameter straight shaft drilled pier is most nearly:

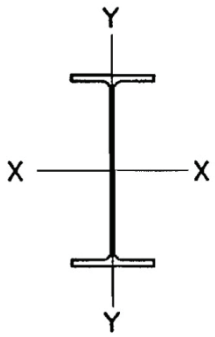
a. 73
b. 92
c. 103
d. 120

533. Using the given subsurface soil conditions and geotechnical properties shown in Figure 1, and the shaft length within the clay layer of 10 feet, the required penetration (feet) into the shale to develop the required pier capacity of 120 kips is most nearly:

a. 4.0
b. 7.0
c. 11.5
d. 14.0

For **Question 534**, refer to the following Beam Loading Diagram and information.





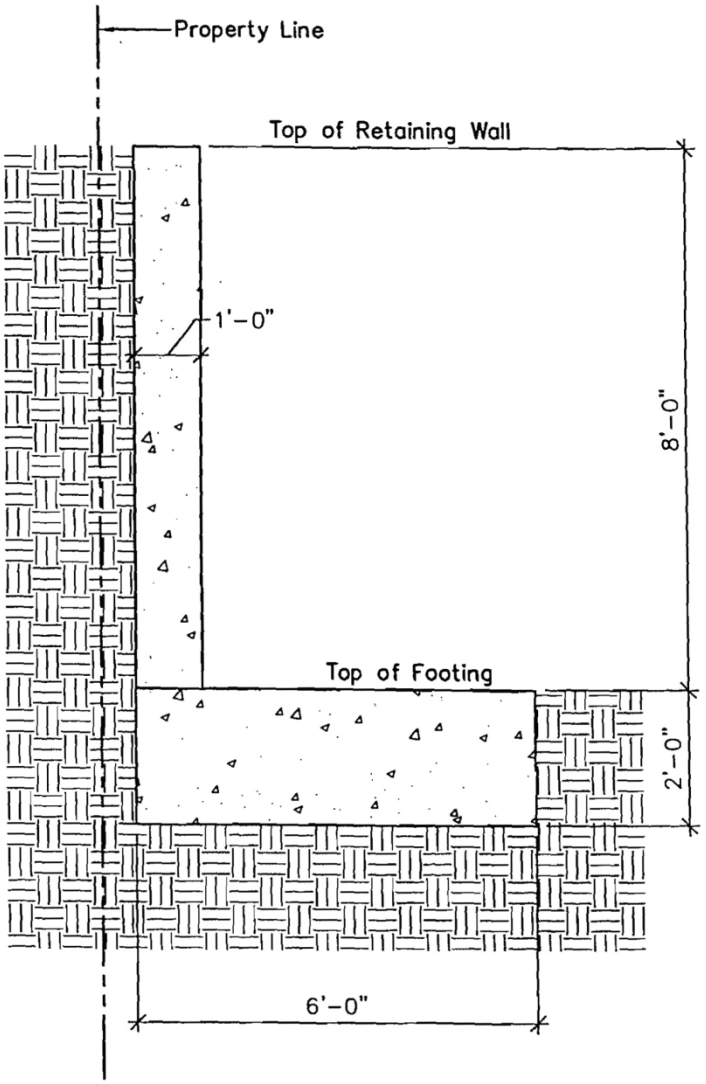
Beam Section

E = 29,000 ksi
Fy = 36 ksi

534. Using the given beam span, loading, and properties, the minimum moment of inertia (in^4) about the x-axis of the given beam to limit the mid-span deflection to 1/2" when using ONLY 75% of dead load is most nearly:

a. 100
b. 375
c. 1,040
d. 1,400

For **Questions 535**, refer to the following details.

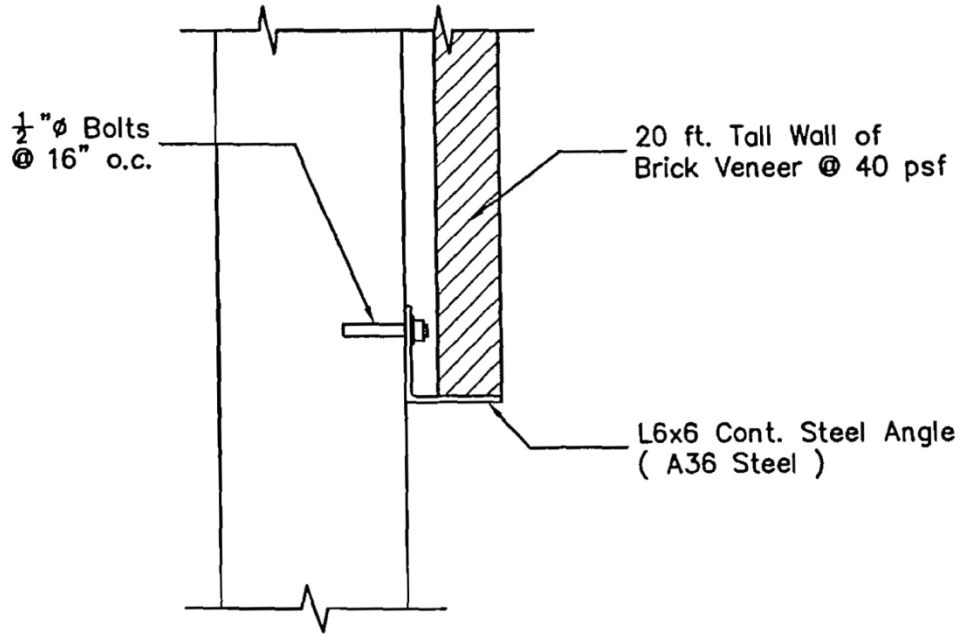


Retaining Wall Section – Figure 1

535. Using the given retaining wall geometry and details in Figure 1, and a 1 foot unit length of the retaining wall, the unfactored moment (lb.-ft.) at the top of the footing due to the lateral earth pressure load of 40 pcf equivalent fluid pressure is most nearly:

a. 3,400
b. 6,600
c. 6,800
d. 10,000

For **Question 536**, use the following diagram and information:

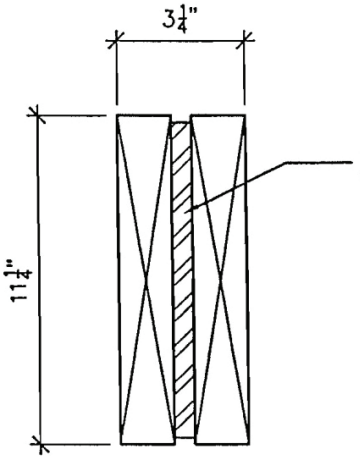


Shelf Angle Diagram

536. Using the given shelf angle diagram and the given information, the shear force on the bolt (pounds) from the weight of the brick is most nearly:

a. 600
b. 800
c. 1,100
d. 1,200

For **Question 537**, refer to the following section and information.



Composite Beam Section

Given Information:

Composite beam is oriented such that loads are applied in the direction of the beams strong axis

Wood members are in dry and conditioned environment

Wood: E = 1,350,000 psi

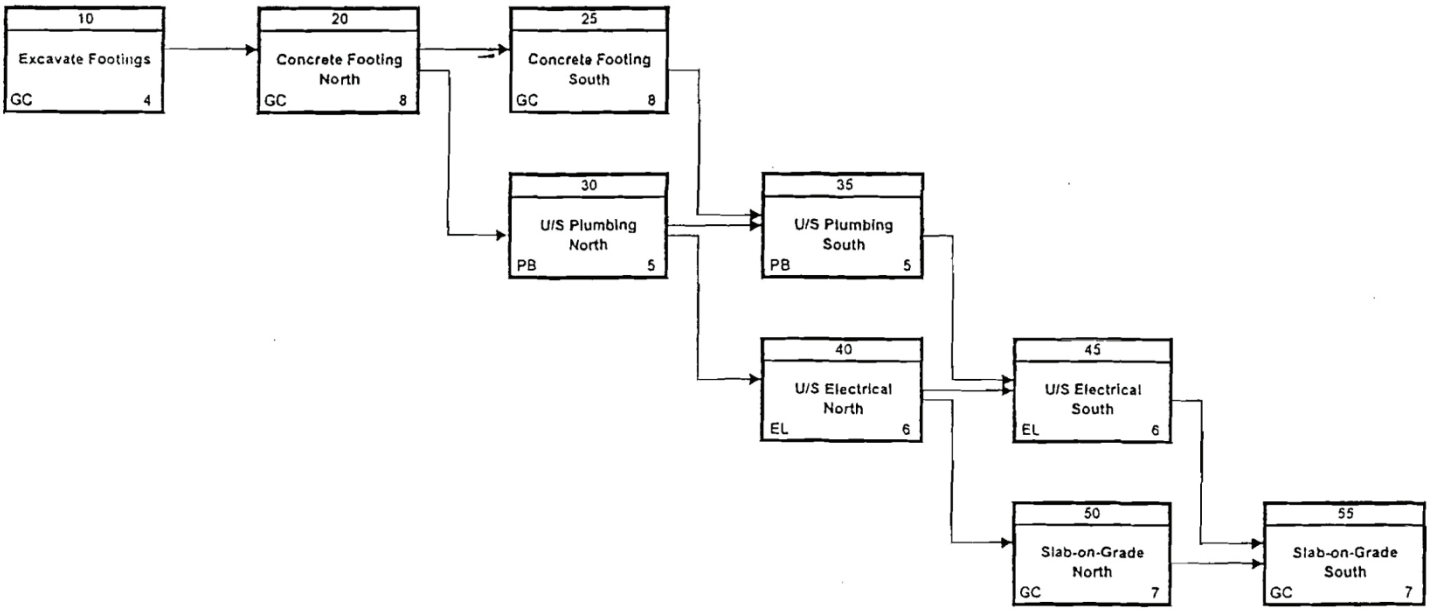
Steel: Fy = 36 ksi

Steel: E = 29,000,000 psi

537. Using the given cross-section and information, a steel plate is sandwiched between two 2x12s and the members are bolted together so the steel plate and wood member act as one unit. The transformed wood moment of inertia (in^4) for the given section is most nearly?

a. 356
b. 384
c. 952
d. 7,680

For **Question 538**, refer to the following diagram.



538. Using the given Precedence Method CPM logic diagram for the construction of a slab on grade. The Activity Duration is shown on the lower right hand corner of the rectangle. The activity number is listed at the top of the rectangle. The activity description is listed in the middle. The responsibility code is listed in the lower left hand corner. For example, Activity #25 Concrete Footing for the South Half of the Building will take 8 days and will be done by the General Contractor (GC).

For the given Precedence Method CPM logic diagram, the total duration (days) necessary to construct the slab on grade is:

a. 35
b. 36
c. 38
d. 40

For **Question 539**, refer to the following Payment Application.

Building Renovation Project

PAYMENT APPLICATION NUMBER: 2

DESCRIPTION OF WORK	SCHEDULED VALUE	WORK COMPLETED			TOTAL COMPLETED AND STORED TO DATE	%	BALANCE TO FINISH	RETAINAGE
		PREVIOUS APPLICATIONS	THIS APPLICATION					
			WORK IN PLACE	STORED MATERIAL				
GENERAL REQUIREMENTS	70,000.00	40,000.00	10,000.00	0.00	50,000.00	71%	20,000.00	5,000.00
DEMOLITION/SITEWORK	12,000.00	12,000.00	0.00	0.00	12,000.00	100%	0.00	1,200.00
CONCRETE	10,000.00	10,000.00	0.00	0.00	10,000.00	100%	0.00	1,000.00
MASONRY	10,000.00	7,500.00	2,500.00	0.00	10,000.00	100%	0.00	1,000.00
ROUGH & FINISH CARPENTRY	20,000.00	0.00	1,500.00	3,000.00	4,500.00	23%	15,500.00	450.00
CAULKING & SEALANTS	4,500.00	3,500.00	1,000.00	0.00	4,500.00	100%	0.00	450.00
DOOR, FRAMES & HARDWARE	25,000.00	0.00	2,500.00	7,500.00				
WINDOWS, GLASS & GLAZING	9,000.00	4,500.00	4,500.00	0.00	9,000.00	100%	0.00	900.00
DRYWALL & CEILINGS	35,000.00	20,000.00	15,000.00	0.00				
FLOORING, VCT & CARPET	10,500.00	0.00	0.00	0.00	0.00	0%	10,500.00	0.00
SPECIAL COATINGS	4,500.00	0.00	0.00	0.00	0.00	0%	4,500.00	0.00
PAINTING	12,000.00	4,000.00	4,000.00	0.00	8,000.00	67%	4,000.00	800.00
SPECIALTIES	9,000.00	0.00	0.00	0.00	0.00	0%	9,000.00	0.00
CASEWORK	12,000.00	0.00	0.00	0.00	0.00	0%	12,000.00	0.00
PLUMBING/HVAC	110,000.00	90,000.00	10,000.00	0.00	100,000.00	91%	10,000.00	10,000.00
FIRE PROTECTION PIPING	14,500.00	14,500.00	0.00	0.00	14,500.00	100%	0.00	1,450.00
ELECTRICAL	90,000.00	70,000.00	10,000.00	0.00	80,000.00	89%	10,000.00	8,000.00
TOTAL	458,000.00	276,000.00	61,000.00	10,500.00	347,500.00	76%	110,500.00	34,750.00

539. The contractor has submitted the given Payment Application No. 2 for the “Building Renovation Project”. The amount of retention withheld from progress payments is 10%. The amount that should be paid this month for Drywall & Ceilings is most nearly: (Assume all previous payments have been paid)

a. $11,500
b. $13,500
c. $15,000
d. $31,500

540. Construction Management Project Delivery Methods include Construction Manager-Advisor Contracts and Construction Manager-At Risk Contracts. The Construction Manager- At Risk is liable to the Owner for:

a. Design Errors & Omissions
b. Differing Site Conditions
c. Force Majeure Weather Delays
d. Contractor Defaults

Solutions for Sample Questions for the Afternoon Portion of the Examination in Architectural Engineering

Test Items 501-540

501. To minimize the transmission of moisture vapor from the subgrade soils into the concrete floor slab.

Correct Answer is: b

502. Locating the sensitive equipment adjacent to a building support column would reduce the impact of vibrations in a floor system by walking.

Correct Answer is: a

503. 6-inch CMU block wall plus 2-inch air space plus 6-inch CMU block wall

STC = 56

Correct Answer is: d

504. Granite
Absorption by weight = 0.40

Correct Answer is: d

505. Hospital with emergency treatment facilities – Occupancy Category IV
IP = 1.5 per 13.1.13
The larger the importance factor the greater the calculated seismic force

Correct Answer is:b

506. 8 x 8 solid sawn timber per Section 602.4.1

Correct Answer is: c

507. Increasing the thickness of the floor slab adds mass to the floor system which would help to dampen the vibrations felt by the building users.

Correct Answer is:c

508. $\sqrt{3} \times \frac{208\ Volts \times 600\ amps}{1{,}000}$ = 216.2 kVA

The minimum standard size transformer is 225 kVA

Correct Answer is: b

509. Current Power Factor, cos theta= $\frac{P}{\sqrt{P^2 + Q^2}}$

Cos theta = $\frac{625}{\sqrt{625^2 + 295^2}}$ = .90

PF = .90
PF = .95 .95 theta = cos - 1 (95) = 18.19

Q_2 = 625 x tan 18.19 = 205.37, say 205
$Q_1 - Q_2$ = 295 - 205 = 90 kVAR

Correct Answer is: a

510. 60 kW + 100 kW + 40 kW = 200 kW
theta = cos - 1 (.707) = 45°
VARS = 100 x tan 45 = 100 Lagging
theta = cos - 1 (.80) = 36.87°
VARS = 40 x tan 36.87 = 30 Leading
$\sum$VARS = 100 - 30 = 70 Lagging
kVA = $\sqrt{200^2 + 70^2} = 211.9$
theata = tan - 1 (70/200) = 19.29
PF = cos 19.29 = .944
211.9 kVA @ .944 Lagging

Correct Answer is: c

511. Diagram B

Correct Answer is: b

512. 20A1P = 120 x 20 x 80% = 1,920 VA, (maximum by code)
1,920/120x4.80 = 3.3 3 luminaries

Correct Answer is: c

513. $\theta_A = 15°$
D = 7.46/cos 15° = 7.72'
$E_A = \frac{I_A}{D^2}$ x sin $\theta_A = \frac{2786}{(7.72)^2}$ x sin 15° = 12.09

E_A = 12.1 fc

Correct Answer is: a

514. $I_{fault} = \frac{22\ MVA}{\sqrt{3} \times 480\ volts} \times (1 \times 10^6) = 26{,}462$ Amps

Next largest is 42,000 Amps

Correct Answer is: b

515. The rotation of vectors is always assumed counter clockwise.

Correct Answer is: c

516. Corresponds with all given parameters when given parameters and applied to NEC tables 430.251 (B) and NEC Table 430.250.

Correct Answer is: c

517. $PF = \frac{HP \times 746}{E \times I \times EFF \times \sqrt{3}}$

$= \frac{100 \times 746}{460 \times 120 \times .092 \times \sqrt{3}}$

$= .848$, say 0.85

518. H = $(8x1170/6x1800)^2$ x 80 = 60.09 feet

Correct Answer is: b

519. According to NFPA 13 (2007) 5.2.2.1, the maximum floor area for an ordinary hazard is 52,000 Square Feet.

Correct Answer is: b

520. A system consisting of variable air volume (VAV) air handling units.

Correct Answer is: c

521. The specific volume of the return air is approximately 13.88 cubic feet per pound of dry air. The mass flow rate is 18,000/13.88 = 1,297 lbm per minute. The specific volume of the outside air is approximately 14.36 cubic feet per pound. The mass flow rate is 2,000/14.36 = 139 lbm per minute.

The total mass flow rate is 1,297 + 139 = 1,436 lbm per minute.

Calculating the mixed air temperature:

1,297 x 80/1436 = 72.2 degrees
139 x 95/1436 = 9.2 degrees
81.4 degrees

At 81.4 degrees on the mixing line on the psychrometric chart, the humidity is 59% RH

81.4° degrees and 59% RH

Correct Answer is: d

522. A condenser loop for an open cooling tower.

Correct Answer is: a

523. A condensing unit contains a condenser fan, condenser coil, and compressor.

Correct Answer is: a

524. The total flow in the distribution loop will decrease by less than 50% as predicted by the intersection of the system curve and the simple pump curve.

Correct Answer is: c

525. The enthalpy of the entering air = 33.6 BTU/lb;
The enthalpy of the leaving air = 22.6 BTU/lb.;
33.6 - 22.6 = 11.0 BTU/lb.

The heat absorbed by the coils = 4.5 x 5,000 x 11.0 = 247,500 BTU/hr.

The heat absorbed by the water = 247,500 = Gallons/hr x 8.34 lbs./gal. x 10°F
Gallons per hour = 2,967
Gallons per minute = 49.5; say 50 GPM

Correct Answer is: b

526. 17.5 foot of head would be the maximum at the conditions indicated. With a 1/2 hp motor, the flow rate would not change. 45 GPM

Correct Answer is: a

527. Increase with increased water flows.

Correct Answer is: c

528. ϕ Vc $\geq$ ϕ Pu Vc = Pu / ϕ ϕ = .75
Pu = 1.2 × 175 + 1.6 × 175 = 490 k
Pu / ϕ = 490/.75 = 653.3^k

Vc = $4\sqrt{f'c}$ x d x b_o = .219 x d x b_o

d = t-4"
b_o = (18+d) 4
653.3 = .219 x d x [(18+d) x 4]
653.3 = 15.77 d + .876 d^2
d = 19.76 inches
t = 19.76 + 4 = 23.76 inches, say 24 in.

Correct Answer is: b

529. M_1 = +2.6^k (12 ft.) = +31.2 k-ft.
M_2 = M_1 - (3.7^k x 20 ft) = 31.2 - 74 = -42.8 k-ft.
M_3 = M_2 + (9.9^k x 12 ft.) = -42.8 + 118.8 = +76.0 k-ft.

Moment Diagram A

Correct Answer is: a

530. Allowable weld stress = 0.3 x 70 = 21 ksi

Effective weld thickness = .707 x .25 = .177 inch

Weld strength = .177 x 21 = 3.71 k/in.

Weld length required = $\frac{20}{3.71}$ = 5.4 inch

Correct Answer is: d

531. A rigid diaphragm means that the load distribution is based on relative stiffness.

ΣF = 150 lb/f x 60 ft. = 9,000 pounds

Σ Stiffness = 3,000 + 4,000 + 3,000 = 10,000 lb./in.

F_A = 3/10 x 9,000 = 2,700 pounds

F_B = 4/10 x 9,000 = 3,600 pounds

F_C = 3/10 x 9,000 = 2700 pounds

Maximum Shear force in diaphragm = 2,700 - 2 (150) = 2,400 lbs.
Maximum required diaphragm capacity = $\frac{2,400}{40}$ = 60 lb./ft.

Correct Answer is: a

532. End bearing area of 18 inch diameter pier = 1.77 ft.^{2}
Circumference of 18 inch diameter pier = 4.71 ft/lin. ft.

Calculate end bearing capacity = 1.77 x 4.0 = 7.1k
Calculate skin friction capacity in clay = 4.71 x 1 x 10 = 47.1k
Calculate skin friction capacity in shale = 4.71 x 2 x 4 = 37.7k
Total pier capacity = 91.9k

Correct Answer is: b

533. End bearing area of 18 inch diameter pier = 1.77 ft.^{2}
Circumference of 18 inch diameter pier = 4.71 ft.^{2}/lin. ft.

Calculate end bearing capacity = 1.77 x 4.0 = 7.1k

Calculate skin friction capacity in clay $= 4.71 \times 1 \times 10 =$ 47.1 k

Σ= 54.2 k

Required friction capacity in shale = 120.0 - 54.2 = 65.8k

Calc. required penetration into shale = $\frac{65.8}{4.71 \times 2}$ = 6.98 feet

Correct Answer is: b

534. $\Delta_{DL} = \frac{5 \times W_{DL} \times \ell^4}{384 \times E \times I}$ = 0.5"

Calc. I required for ½" deflection when using only 75% of dead load.

$I = \frac{5 \times (1.1 \times .75) \times (30)^4 \times (1728)}{384 \times 29{,}000 \times .5}$ = 1,037 in.^{4}

Correct Answer is: c

535. Equivalent fluid pressure of 40 pcf has a triangular distribution

Moment at top of footing =40 x 8 x $\frac{8}{2}$ x $\frac{8}{3}$ = 3,413 # - ft./ft.

Correct Answer is: a

536. Weight of brick = 20' x 40 psf = 800 lbs./ft.

Anchors at 16" on center.

Shear Force per bolt = 800 x 1.33 = 1,064 pounds, say 1,100 pounds.

Correct Answer is: c

537. $n = \frac{E\ steel}{E\ wood} = \frac{29{,}000{,}000}{1{,}350{,}000} = 21.5$

$I = \frac{bh^3}{12}$(wood) + $\frac{bh^3}{12}$(steel) x n

$$\frac{3(11.25)^3}{12} + \frac{.25(11)^3}{12}(21.5)$$

$356 + 596 = 952$ in.^{4}

Correct Answer is: c

538. The total duration necessary to construct the slab on grade is calculated as the longest path through the network.

Activities:	10 - Excavate Footings	4 days
	20 - Concrete Footings North	8 days
	25 - Concrete Footings South	8 days
	35 - Underslab Plumbing South	5 days
	45 - Underslab Electrical South	6 days
	55 - Slab on Grade South	7 days
		38 days

Correct Answer is: c

539.

Total Completed and Stored to Date Through Payment Application No. 2	$35,000.00
Total paid on previous Application	$20,000.00
Amount Due before Retention	$15,000.00
Total Retention Withheld through Payment Application No. 2	$ 3,500.00
Amount of Previous Retention from Payment Application No. 1 10% x 20,000.00 =	$ 2,000.00
Amount of Retention withheld from Payment Application, No. 2	$ 1,500.00
Amount Paid this Month for Drywall and Ceilings (15,000 - 1,500)	$13,500.00

Correct Answer is: b

540. Contractor Defaults

If a contractor defaulted that was under contract to a CM at Risk, the CM would become responsible to complete the work. If the contractor was bonded, the CM may take action against the bond to try and force the bonding company to step in and complete the work of the defaulted contractor for the CM. A Construction Manager - at Risk holds contracts. A Construction Manager - Advisor does not hold any contracts. All contracts are prime with the Owner.

Correct Answer is: d

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Reference Material

Engineering Economy textbook containing equations and tables related to time value of money.

International Building Code, 2006 Edition, International Code Council, Inc.

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ASCE 7, Minimum Design Loads for Buildings and Other Structures, 2005 Edition, American Society of Civil Engineers.

ASHRAE Fundamentals Handbook 2005, American Society of Heating, Refrigeration, & Air-Conditioning Engineers

ASHRAE HVAC Applications Handbook 2007, American Society of Heating, Refrigeration, & Air-Conditioning Engineers

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ASHRAE Refrigeration Handbook 2006, American Society of Heating, Refrigeration, & Air-Conditioning Engineers

ASHRAE Principles of Heating, Ventilating and Air-Conditioning, American Society of Heating, Refrigeration, & Air-Conditioning Engineers

ANSI/ASHRAE/IESNA Standard 90.1-2007 - Energy Standard for Building Except Low-Rise Residential Buildings, American Society of Heating, Refrigeration, & Air-Conditioning Engineers

IEEE Color Books Set, Latest Editions, Institute of Electrical and Electronic Engineers

IESNA Lighting Handbook 9th Edition, Illuminating Engineering Society of North America

SFPE Handbook of Fire Protection Engineering, 2008 Edition, Society of Fire Protection Engineers

ASPE Data Book Volume 1: Fundamentals of Plumbing Engineering, American Society of Plumbing Engineers

ASPE Data Book Volume 2: Plumbing Systems, American Society of Plumbing Engineers

ASPE Data Book Volume 3: Special Plumbing Systems, American Society of Plumbing Engineers

NFPA 70 National Electric Code, 2008 Edition, National Fire Protection Association

NFPA 13 Standard for the Installation of Sprinkler Systems, 2007 Edition, National Fire Protection Association

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NFPA 72 National Fire Alarm Code, 2007 Edition, National Fire Protection Association

NFPA 99 Standard for Health Care Facilities, 2005 Edition, National Fire Protection Association

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ACI 318, 2005 Edition, Building Code Requirements for Structural Concrete, American Concrete Institute

ACI 530, 2005 Edition, Building Code for Masonry Structures, American Concrete Institute

ACI 530.1, 2005 Edition, Specification for Masonry Structures, American Concrete Institute

AISC Steel Construction Manual, Thirteenth Edition, American Institute of Steel Construction, Inc.

NDS, National Design Specification for Wood Construction & National Design Specification Supplement, 2001 Edition, ASD, American Forest & Paper Association.

PCI Design Handbook, Sixth Edition, Precast/Prestressed Concrete Institute