ARCH 631. Study Guide for Final Examination

This guide is not providing “answers” for the conceptual questions. It is a list of topical concepts and their application you should be familiar with. It is an *aid* to help prepare for the final exam.

**Material not previously covered by mid-term exam study has bold section headers.**

### Steel Design

- Design methodologies
- Steel grades (standard properties)
- Yield strength vs. ultimate strength
- Local buckling in web & flange
- Bearing on flange
- Plastic section modulus
- Plastic moment & plastic hinges
- Braced vs. unbraced length
- Use of beam moment capacity charts
- Equivalent uniform load based on maximum moment
- Slenderness criteria & l/r
- with respect to least radius of gyration
- Compact section criteria
- Use of column load capacity charts
- Beam-columns
- Interaction equations (P-Δ)
- W (first number meaning) x (second number meaning)
- Bolt designations
- Gross area
- Effective net area

### Masonry Design

- Design methodology
- The fact that masonry can resist tension without steel!
- Brick, block, CMU, etc.
- Grout vs. mortar
- MASONWORK
- Masonry strength (prisms)
- Grouting cover and purpose

- Area of web
- Connection types
- Weld strengths
- Throat thickness
- Fillet, butt, plug, slot
- Coping
- Tension member
- Simple shear connector
- Single vs. double shear
- Capacity of a connection
- Block Shear Rupture
- Design vs. analysis
- Decking
- Gusset plates
- Web stiffener plates
- Open web joists and use of design charts
- Equivalent uniform load from maximum moment
- Column base plate dimensioning
- Beam shear splice
- Eccentrically loaded bolt group

- Moisture and clay unit durability
- Combined stresses for walls
- Virtual eccentricity
- Lintels and arching action + load distribution
- Interaction equations (P-Δ)
- Pilasters
- Design vs. analysis
### Foundation Design
- Design methodology (separate from reinforced concrete design)
- Net soil pressure vs. allowable soil pressure
- Overburden
- Sliding and overturning (stability)
- Settlement
- Active vs. passive pressure
- Foundation types
- Foundation parts (key, counterfort, etc...)
- Shallow foundations vs. deep foundations
- Kern and pressure distribution
- Shear resistance and bearing resistance of piles
- Design vs. analysis
- Reinforced concrete design for shear and bending
- One-way vs. two-way shear (load & strength)
- Location of maximum shear in beams & footings
- Location of maximum moment in footings
- Embemt length
- Bearing and dowels

### Structural Supervision
- Steel grade
- Concrete mix design & slump
- Concrete cylinders
- Masonry prisms
- Clear (of grout) cavities for moisture
- Protection of timber from weather
- Bracing during construction
- Tolerances for assembly

### General: Systems
- One-way vs. two-way systems
- Truss configurations and assumptions for analysis
- Zero-force member
- Special truss member configurations at joints and conditions
- Basis of graphical truss analysis (aka Maxwell’s diagram)
- Compound truss
- “Cable” truss members
- “Shear & Moments” in parallel chord trusses
- Lenticular truss
- Vierendeel “truss”
- Catenary shape, sag
- Cable-stayed
- Pinned arches (2 vs. 3) & rigid arches
- “Thrust”
- Rigid vs. non-rigid pinned frames
- Rigid frame behavior
- Connection types and load/moment transfer
- Moment “redistribution”
- Methods for analysis of statically indeterminate frames
- Effect of relative frame member stiffnesses
- Types and purpose of bracing
- Sidesway
- Bearing, shear, curtain walls ...
- Cantilever method with lateral forces

### General: Columns
- Stability
- Buckling vs. crushing
- Slenderness
- Critical Buckling and Euler’s Formula
- Effective length, K & bracing (end conditions)
- Beam-Columns (eccentric loading)
- Combined bending and compression – interaction equations or diagrams
- P-∆ effect
- Eccentricity
- Kern
Statics & Mechanics

- Vectors and scalars
- Parallelogram law
- Tip-to-tail method
- Internal vs. external forces
- Tension and compression
- Resultant of a force
- Component of a force
- Moment of a force
- Moment of a distributed load
- Moment Couple
- Equivalent Force Systems
- Concurrent vs non-concurrent force systems
- Equilibrium
- Newton’s First Law
- Direction and type of force in a cable with relation to geometry
- Free Body Diagram
- Reactions at a support and relationship to motion prevented
- Statically Determinate vs. Indeterminate
- Two-force bodies and relationship to loads
- Three-force bodies
- Fixed-end moment reactions
- Pin connections
- Method of Joints
- Method of Sections
- Actions vs. reactions
- Internal shear, axial force & bending moment
- Inflection point on moment diagram
- Effect of forces on shear diagram
- Effect of moments on moment diagram
- Location of zero shear (x) and relation to maximum moment
- Slope relationships with integration
- Normal stress (compression & tension)
- Shear stress (non beams)
- Bearing stress
- Bending & shear stress (beams)
- Torsional (shear) stress (with respect to shape and where maximum occurs)
- Relation of strain to stress & Modulus of Elasticity
- Brittle, Ductile & Semi-brittle material behavior
- Yield strength (or point & proportional limit)
- Elastic vs. plastic range
- Ultimate strength
- Strength vs. stress
- Rupture / Fatigue behavior
- Creep
- Orthotropic vs. Isotropic vs. Anisotropic materials
- Stress concentration
- Thermal vs. elastic strains
- Geometric constraints
- Serviceability
- Buckling
- Deflections & elongation
- Stiffness (relative to EI/L through Δ, or AE/L through δ)
- Superpositioning
- Single vs. double shear

General: Planning

- One-way vs. two-way systems
- “Collectors”
- Vertical & horizontal grid considerations
- Long span considerations
- Effect of loading types on system efficiency
- Options for corners, large spaces, etc.
- Integration with building services
- Fire safety and planning
- “Weakness” Areas (Tolerances, Lateral bracing, etc.)
### General: Design

- Allowable Stress Design
- Load and Resistance Factor Design
- Factored loads
- Resistance Factors
- "Design" values vs. "Capacity"
- Factor of Safety
- Density of materials and relation to weight
- Load types (and directions) 
  *(like D, L, S ...)*
- Minimum loads (building codes)
- Load combinations
- Serviceability and limits (ex. ponding)
- Live load reduction
- Building codes vs. standards vs. structural codes
- Stability of systems & members
- Design vs. analysis
- Efficiency
- Load tracing & (con)tributary width (vs. area)
- Static vs. dynamic loads
- Equivalent static wind load & pressure
- Concentrated loads
- Distributed loads – uniform / non-uniform
- Result of acceleration on a mass and Weight
- Period of vibration, frequency, damping & resonance

### General: Beams

- Simply supported
- Overhang
- Cantilever
- Continuous
- $w$ vs. $W$
- Equivalent center of load area
- Built-up shape
- Centroid, moment of inertia, $Q$, radius of gyration
- Neutral axis, section modulus, extreme fiber
- Negative area method
- Parallel axis theorem
- Maximum bending stress (& location along length and in cross section)
- Maximum shear stress (& location along length and in cross section)
- Maximum shear stress by beam shape (proper equations)
- Shear flow and shear center
- Lateral buckling (and bracing)
- Torsion stresses and cross section shape
- Stress types in beams
- Self-weight
- Deflections & superpositioning (+ units)
- Use of Beam Diagrams and Formulas
- Principal stresses
- Efficient cross-section shapes
- Shaping a beam along the length for efficiency.
- Location of supports and efficiency.
- "Effective length" and points of inflection
- Methods for analysis of statically indeterminate beams
- Support settlements and stress redistribution
- Loading patterns for spans

### General: Membranes & Shells

- Appropriate loads & primary stresses
- Air-supported vs. air-inflated
- Materials, durability, and punctures
- Profiles and wind effects
- Shell vs. not shell (stresses are key)
- Meridional vs. Hoop
- Shell forces vs stresses (with respect to thickness and strips)
- Tension vs. compression rings
- "Thrust"
- Buckling and “snap-through”
- Anticlastic shell properties
- Pressure vs. membrane stress
- Curvature and membrane stress
- Hyperbolic paraboloid
### General: Plates & Grids

- Plate vs. slab
- One-way vs. two-way behavior
- Aspect ratio (with respect to bay dimensions)
- Space frame vs. grid
- Unit width for design
- Moment redistribution
- Pan joists, T sections & effective width of flange
- Drop panels
- Boundary conditions & effect on deflections / moments
- Point loads and effect on deflections / moments
- Simplified Frame Analysis & “Strip” method
- Design shear & moments (spans “integral with support”, first interior support, etc.)
- Direct design method for two-way slabs & \( M_0 \)
- Solutions for large shear at space frame supports
- Moment of inertia with respect to folded plates
- Reason for stiffening of folded plates
- Live load reduction
- Thickness as a fraction of bay span (L)
- “Punching” shear at columns

### Reinforced Concrete

- Cast-in-place, precast, prestressed (pretensioned), post-tensioned
- Constituents to make concrete
- Slump
- Behavior in compression vs. tension of concrete
- Design methodology
- 28-day compressive strength
- Term “working stress design”
- Creep
- Camber (hogging & sagging)
- “composite”
- Transformed section
- Depth of the Whitney stress
- Moment capacity (or ultimate strength) vs. nominal moment (or strength)
- Factored design moment (or shear or ....)
- Design stress in reinforcement
- Design stress in concrete
- Reinforcement grades
- Reinforcement ratio
- Effective depth vs. depth of a beam
- Under-reinforced vs. over-reinforced
- Balanced-steel condition
- Purpose of minimum reinforcement area requirement
- Why development length is necessary
- Use of Strength Design Curves (\( R_n \))
- Purpose of stirrup requirement when concrete capacity is available
- Diagonal tension cracks
- Stirrup strength
- Shrinkage
- Concrete cover and purpose
- #3 bar (meaning of the numeral)
- Purpose of compression reinforcement
- T-section behavior and stresses in flange
- One-way joists, vs. beams, vs. girders
- “Spandrel”
- One-way slab design and “unit” strip
- One-way vs. two-way slabs
- One-way vs. two-way shear (load & strength)
- Plate vs. Flat Slab
- Continuous beam analysis with coefficients
- Clear span / span length
- Columns with ties vs. spirals (stresses, factors, etc.)
- Interaction diagrams (P-\( \Delta \))
- Location of maximum shear in beams
- Live load reduction
- Beam self weight relationship to material density (150 lb/ft\(^3\))
- Design vs. analysis
### General: Lateral Loads

- Lateral stability vs. gravity loading
- Resisting mechanisms
- “In-plane” forces
- Load transfer and shear planes
- Torsional deformations
- Horizontal vs. vertical shear planes
- Diaphragm action
- Diaphragms, shear walls, bracing, frame action, drag struts, chevron, knee, etc.

- Selective placement of horizontal and vertical rigid planes
- Member orientation for frame action
- Mechanism choices with building height
- Behavior of multistory frames under lateral load.
- Behavior of “tubes”
- Serviceability issues, dampers

### Hazards Design

- Equivalent static wind pressure, direction, size with respect to building height, formula
- Wind speed & 50 year return period
- Vortex shedding
- Flutter
- Windward, leeward
- Flood zones & “100 year flood”
- Hydrostatic pressure calculation (linear with depth of water by density \( \gamma h \))
- Dynamic loads
- Fault zones, focus (hypocenter), epicenter
- Magnitude, duration, intensity of ground motion
- Liquefaction, landslides, subsidence, tsunami
- Inertial forces (mass, acceleration)
- Base shear and code formulas

- Overturning
- Resonance, frequency, period of vibration, damping
- Stiffness - lateral and torsional
- Center of mass, center of rigidity
- Drift and shear distribution by floor mass
- Pounding, re-entrant corners, soft stories
- Seismic joints, base isolation, tuned mass dampers
- Period length relationship to stiffness
- “Spring-mass” assembly model
- Redundancy and continuity
- Non-structural elements contribution to stiffness
- Spectrum or spectral response
- NEHRP (actual name and function)

### General: Connections and Tension Members

- Normal stress (compression & tension)
- Shear stress (non beams)
- Bearing stress
- Pinned joint vs. rigid joint
- Single shear vs. double shear
- Simple shear connector
- Connected area for longitudinal shear stress calculation
- Nail capacity and pitch for resisting longitudinal shear
- Effective area vs. net area vs. gross area of tension member

- Forces and stresses resisted by nails, adhesives, split ring connectors, bolts, etc.
- Rupture vs. yielding in steel
- Bolt designations
- Weld strengths
- Throat thickness
- Fillet, butt, plug, slot
- Coping
- Block shear rupture
- Web “crippling”
<table>
<thead>
<tr>
<th>Timber Design</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumber vs. engineered timber characteristics</td>
<td>Column stability factor, $F_{CE}$ &amp; l/d</td>
</tr>
<tr>
<td>(ex: glulam)</td>
<td>Interaction equations (P-Δ)</td>
</tr>
<tr>
<td>Light-frame vs. heavy timber construction</td>
<td>Connection stresses</td>
</tr>
<tr>
<td>Lumber grading</td>
<td>Design vs. analysis</td>
</tr>
<tr>
<td>Various strengths (directionality, wood type, etc.)</td>
<td>Bolt designations</td>
</tr>
<tr>
<td>Built-up member types</td>
<td>Effective net area</td>
</tr>
<tr>
<td>Design methodologies and obtaining allowed stresses</td>
<td>Connection types</td>
</tr>
<tr>
<td>(adjustment factors - duration, multiple member use...)</td>
<td>Single vs. double shear</td>
</tr>
<tr>
<td>Creep</td>
<td>Bolt capacity charts and relation to wood strengths</td>
</tr>
<tr>
<td>Nominal dimensions</td>
<td>Allowable shear capacity charts for diaphragms</td>
</tr>
<tr>
<td>Beam self weight with respect to material density</td>
<td>Chord forces in diaphragms</td>
</tr>
<tr>
<td>(variable for wood types)</td>
<td></td>
</tr>
</tbody>
</table>