

Element Z | General Design Requirements

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PART 1 - GENERAL REQUIREMENTS

1.01 OVERVIEW

- A. Load Reductions – Structures built for Owner must be designed for loads large enough to permit wide flexibility in their functions, and as such are subject to increased loads and high sustained live loads. Loads are often applied to large areas of usable floor space (thereby making liberal live load reduction factors undesirable).
- B. Deflections - Live loads and deflection limitations must be assumed to accommodate these conditions of design. Care must be exercised in control of immediate and long-time deflections to prevent immediate and future damage to non-structural elements attached to the structure.
- C. Building Codes - The more stringent design requirements between the applicable building codes and these guidelines shall be used. The latest issue of the International Building Code (IBC) shall be used unless otherwise directed by the Owner's Project Manager.
- D. Document Review Schedule - The A/E will be required to present the Drawings and Specifications for review to Owner at the intervals outlined in Element Z2010 of these Guidelines. Intermediate reviews may be required if the scope of the Project has been changed or if an earlier review found the Drawings and Specifications unacceptable either as a whole or in part.
- E. Review Meetings - The Structural Engineering Consultant(s) (Engineer) will participate in all reviews, Work sessions and presentations where this discipline is involved. Items to be included for review at each phase or stage of completion are outlined in Element Z2010.
- F. Consistency of Design Assumptions – Design assumptions made for efficiency in analysis must be carried through the design and proportioning of the actual members. The design assumptions must be consistent with Owner's goals. For example, the practice of designing pan joists or ribbed slabs as "tee beams" may save slightly in the cost of the reinforcing bars in the pan ribs. This practice, however, compromises future flexibility of the structure in terms of slab penetrations between the ribs. Another example would be the assignment of large bending moments to columns for the sake of beam design, and then neglecting these beam moments when designing the columns.
- G. Structural Integrity – The structural system selected should be adequately described and detailed such that all parts of the facility are incorporated and connected with the structure so as to allow the facility to function as a unit under extreme service conditions. An example would be in the cases for exterior cladding and roofing systems, which must be adequately fastened to the structure to resist the worst case loading conditions, but which also must be detailed to avoid distress under more typical thermal and moisture exposures. It makes little sense to design a roof system capable of resisting 90 or 120 mph winds unless the connections to the structure and the structure itself are substantial enough to resist the loads to be transferred.
- H. Verify with Owner representative location of any of the following and plan accordingly:

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1. Folding Door (partition)
2. Projection Screen
3. High Density Filing Units

1.02 RENOVATION WORK

- A. Structural demolition Drawings shall be included.
- B. All penetrations of existing structural components shall be shown in the structural Drawings. Reinforcement of these structural components shall be designed and detailed as required. Drawings shall show all original framing in the areas near the new penetrations.
- C. Drawings shall show all original structural framing with new framing superimposed. Clearly show original framing to remain in place.
- D. Where portions of an existing structure are required to be completely demolished, Drawings shall show all original structural framing and provide adequate details clarifying location of concrete saw cuts and details of any enforcement required.
- E. Small penetrations of existing concrete slabs (cores for pipes, saw cut openings for ductwork, etc.) shall require the Contractor to drill pilot holes to verify that these penetrations will not cut beams or joists. Use of Ferroskan or ground penetrating radar is recommended as a precaution to help identify conduit which may be embedded in concrete. Note: Neither Ferroskan nor radar can differentiate between metal rebar and conduit.

PART 2 - LOADING AND DEFLECTION STANDARDS

2.01 GENERAL

- A. All roofs shall be designed with sufficient slope or camber to assure adequate drainage after long-time deflection from dead load or shall be designed to support maximum loads including possible ponding due to deflection.
- B. Structural systems and members shall be designed and detailed to accommodate the specific mechanical, electrical, and other equipment as specified by the Architect. All substitutions resulting in changes in the magnitude or location of these loads, or in the revision in the number, location, or size of penetrations through structural elements shall be coordinated by the Contractor at Contractor's expense including providing design calculations by a registered professional engineer addressing the proposed substitution.
- C. Reduction of Live Loads:
 1. No reduction shall be applied to the roof live load.
 2. No reduction of the live load shall be allowed in the design of any slabs or joists.

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3. In designing a column, girder, truss, wall, pier or foundation carrying more than one floor, the live loads of the floors which are supported by such members may be reduced, except in buildings used for storage or warehouse purposes and in open parking decks. The reduced load shall be not less than the following percentages of the live load for which such floors were designed:
 - a. 100 percent for members carrying one (1) floor,
 - b. 90 percent for members carrying two (2) floors,
 - c. 80 percent for members carrying three (3) floors,
 - d. and at corresponding decreasing percentages for each successive floor.
 - e. In no case, however, shall the load be less than seventy percent of the live load for any floor in buildings of occupancies other than those for which specific provision is made herein.
 4. Except as noted above, beams, girders and trusses shall be designed to support the full dead and live loads; provided that in buildings other than those used for storage or warehouse purposes and open parking decks, beams, girders or trusses carrying three hundred square feet or more of tributary floor area may be designed to carry eight-five percent of the live load and the full dead load. This load reduction shall not be used in addition to reduction set forth above.
- D. Wind Loads:
1. The integral structural parts shall be designed to resist the total lateral loads in design for wind. Non-structure elements shall be sufficiently attached to the structural framing system to prevent shedding of components in a design loading event.
 2. Buildings and structures shall be designed to withstand the minimum horizontal and uplift pressures set forth in the latest edition of the IBC. The IBC wind design parameters shall be clearly indicated on the design drawings.
 3. If the building, structure, or components thereof is in a location considered by the Engineer, or Owner, to be unusually exposed, higher wind loads may be specified.
 4. For all Projects, metal roof deck connections shall also meet Factory Mutual's connection requirements. RE: FM Global, Property Loss Prevention Data Sheets 1-29, Roof Deck Securement and Above-Deck Roof Components, Section 2.2.13
- E. Seismic and Geologic Factors – Notify Owner if seismic or unusual geologic conditions occur that would affect the design of the structure.
- F. Control of Deflection - Steel:
1. Design Structural steel members in accordance with A.I.S.C. Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, latest edition with the following exceptions:

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<u>Roof and Floor Load</u>	<u>Maximum Deflection</u>
Live Load Only	1/360
Dead Load and Live Load	1/240

2. It is preferred that flexural members be selected with sufficient depth and stiffness to deflect approximately 1/360 maximum under dead load plus live load conditions. If in the Engineer's judgment this requirement creates unreasonable cost or aesthetic problems, 1/240 may be used.
- G. Ponding and Vibration - Use A.I.S.C. Manual of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, latest edition. Engineer shall use due regard in proportioning to resist vibration to avoid occupancy discomfort due to transient live load vibrations.
- H. Control of Deflection - Concrete:
1. Reinforced concrete members subject to bending shall be designed with adequate stiffness to limit deflections or any deformations as set forth in building Code Requirements for Reinforced Concrete (ACI 318 - latest edition), except that the following Allowable Deflection Table shall govern.

Type of Member	Deflection To Be Considered	Deflection Limitation
Flat roofs not supporting or attached to non-structural elements likely to be damaged by large deflections.	Immediate deflection due to live load, L	1/240**
Floors not supporting or attached to non-structural elements likely to be damaged by large deflections.	Immediate deflection due to live load, L	1/360
Roof or floor construction supporting or attached to non-structural elements likely to be damaged by large deflections	That part of the total deflection which occurs after attachment of the non-structural elements, the sum of the long-time deflection due to all sustained loads and the immediate deflection due to any additional live load.*	1/480***
Roof or floor construction supporting or attached to non-structural elements not likely to be damaged by large deflections.		1/360****

* Total long-time deflection may be reduced by the amount of deflection which occurs before attachment of the nonstructural elements. This amount shall be

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determined on the basis of accepted engineering data relating to the time-deflection characteristics of members similar to those being considered.

** This limit is not intended to safeguard against ponding. Ponding should be checked by suitable calculations of deflection, including the added deflections due to pond water, and considering long-time effects of all sustained loads, camber, construction tolerances and reliability of provisions for drainage.

*** This limit may be exceeded if adequate measures are taken to prevent damage to supported or attached elements.

**** But not greater than the tolerance provided for the nonstructural elements. This limit may be exceeded if camber is provided so that the total deflection minus the camber does not exceed the limitation.

2. Assume a minimum 50 percent of live load as acting with sustained load.

PART 3 - STRUCTURAL ELEMENTS

3.01 GENERAL

- A. This Section consists of various systems and details, which Owner prefers to use or avoid as stated. While it is not the intent that these items must be included or excluded from consideration, they are listed to assure special attention be given to them in order to eliminate recurrent problems. A thorough discussion of the merits of possible structural systems should be held early in the design process.

3.02 FOUNDATIONS

- A. Avoid pre-cast pre-stressed piling.
- B. Avoid slab-on-fill in areas of expansive soils. If a slab-on fill is approved then it shall include a 10 mil vapor barrier which meets ASTM E1745 standards
- C. Avoid the use of waxed cardboard carton forms to form a void space for isolation purposes at active soils.
- D. Avoid pan-joint and/or particularly waffle-joint systems where extensive penetration of floors will occur. Skip-joints, with clear rib dimensions of at least 48 inches, are preferred.
- E. Avoid two-way post-tensioned systems such as banded flat plates. These highly optimized systems do not lend themselves to future penetrations and live load changes and will be used only with written authorization from Owner. Post-tensioning is an appropriate choice for some applications such as in a girder/skip-joint ribbed slab. In many cases, the overall building systems Work best when the girders supporting the skip-joints are maintained at a depth no greater than the skip-joint ribs. For longer spans, post-tensioning is helpful in controlling the deflections of the girder without deepening it past the pan rib depth. The consulting structural engineer shall present various options for consideration at the Schematic and Design

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Development stages which considers various approaches in lieu of girders deeper than the pan ribs. A preference hierarchy would go something like this:

1. Post tensioning
 2. Deep girders
 3. Cambered formwork
 4. Haunch Girders.
 - a. Combinations of these four approaches shall not be used without specific written approval by Owner.
- F. Avoid pre-cast – pre-stressed double-tees. Use only with written authorization from Owner. The decision to use pre-cast double tees in lieu of CIP framing shall be made based on cost-benefit analysis for life cycle costing for a 50 year life cycle; with the exception of parking structures.
- G. Avoid excessive span/depth ratios to minimize deflections and to keep the system rigid.
- H. Avoid the practice of designing pan joists or ribbed slabs as “tee beams” because this practice comprises future flexibility of the structure in terms of slab penetrations between ribs.
- I. Avoid the assignment of large bending moments to columns for the sake of beam design and then neglecting these beam moments when designing the columns.

3.03 CONCRETE SYSTEMS

- A. Avoid structural suspended slabs less than 5 inches thick.
- B. Strive to use standard depth for girders joists and obtain a “flush” bottom structure so that joists and beams are the same depth throughout the structure. The savings in formwork usually more than offsets the expense of extra concrete.
- C. Avoid sprayed-on fireproofing requiring a monolithic finish on thin slab, pan joist or waffle-joist systems.

3.04 STRUCTURAL STEEL FRAMING

- A. Avoid light steel structures with long-span joists without positive shear diaphragm roof, such as metal decking.
- B. Avoid columns without seat angles for beam and girder connections.
- C. Avoid full penetration field welding (both in the shop and field) without strict specification to welder qualification, welding procedures, and inspection and testing, including X-ray testing.
- D. Avoid all “weathering” steel including “weathering” sheet metal.

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- E. Avoid higher strength steels other than ASTM A992 Grade 50 for W – shaped members, ASTM A500, Grade B, 46 ksi. Steel for tube shaped members and A36 steel for miscellaneous plates and members.
- F. Avoid ASTM A-490 bolts.
- G. Avoid high-strength bolted connections without investigating and specifying latest state-of-the-art methods of bolt tightening, inspection, and documentation.
- H. Avoid use of touching dissimilar metals conditions in all structural situations. Use compatible metals or provide isolation devices.
- I. Clearly identify Architecturally Exposed Structural Steel (AESS) and provide appropriate specifications and details. Minimize the use of AESS to reduce cost.

3.05 PRE-CAST CONCRETE

- A. Avoid extra longspan floor members or very large wall panels without thorough research as to transport route from various supply sources, traffic congestion on campus, availability of local machines capable of handling, etc.
- B. Avoid the use of systems that are unfamiliar to the local construction trades.
- C. Avoid systems that are flimsy or difficult to support and to attach.
- D. Avoid light weight concrete (weight less than 145 pcf) without written authorization from Owner.
- E. Avoid the use of epoxy coated rebar.

3.06 CAST IN PLACE CONCRETE

- A. Avoid the use of grade 80 rebar, full penetration weld splices, and bar spacing which provides less than 1-1/2 inch clear separation. Should this prove unavoidable, specify ¾ foot maximum aggregate and 1 inch clear separation. Lap splices on column bars or use cad-weld or acceptable mechanical devices where possible.
- B. Avoid light weight structural concrete with monolithic finish.
- C. Avoid the use of several concrete strengths for structural elements. Limit upper working stress to 6,000 psi unless approved in writing by Owner.
- D. Avoid architectural cast-in-place concrete with conventional reinforcement cover. Use a 2 inch minimum cover in addition to rustications. Provide 4-1/2 inch minimum clearance for vibrators. Tie wires must not have long free ends and must be bent away from concrete faces. Clipped ends must be removed from forms prior to concrete placement.
- E. Avoid the use of sandblasted concrete without written approval by Owner. If approved, use stainless steel or plastic bolsters.

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- F. Avoid the repair of cracks in architectural concrete with conventional caulking compounds. Repairs shall be made by low pressure epoxy material.
- G. Fly-ash in structural concrete shall be used only with written permission by Owner for architecturally exposed concrete. For all other concrete, a maximum of 25 percent (by weight) of type C or F fly ash may be used. The fly ash shall come from a TxDot approved source and shall include monthly mill certificates to confirm the adequacy of the ash.
- H. Dapped beam and corbels in lieu of double columns at expansion joints.

3.07 MASONRY

- A. Avoid light gage metal stud backup for exposed masonry veneer (especially brick). CMU is the preferred masonry backup. Use light gage metal stud backup only with written authorization from Owner. When allowed, the light gage framing shall limit deflections under service wind loads to 1/1000.
- B. The use of masonry cement is not allowed. Use Portland cement only for mortar.
- C. Type "N" mortar is preferred. Type "S" mortar should only be used when absolutely necessary since it is less durable than type "N" mortar.
- D. Mortar cube testing and prism testing are not reliable indications of the in-place strength of the masonry. They are, however, used by our inspectors as a quality control measure and should be included in our testing requirements.

PART 4 - ENGINEERING TESTING

4.01 GENERAL

- A. During design, it will be necessary for Owner to provide the A/E with "Pre-Design Engineering Information." Requests for these services as deemed necessary by the A/E should be made to Owner. Owner will select a qualified Engineering Testing Firm to provide the A/E with information when required.
- B. It is the Owner's practice to assign Owner's own personnel to both "represent the Owner" and provide for inspection during project construction. An independent, commercial testing agency will be selected by and paid for by Owner to provide the engineering testing and materials inspection during construction. These services provide the Owner, A/E and the Contractor with unbiased, third party, technical information and also augments Owner personnel in specific technical inspections.

4.02 PRE-DESIGN TESTING

- A. Sub-Surface Investigations for Foundations: The prime purpose of a sub-surface investigation for foundation design is to accomplish an efficient use of natural, in place materials for the support of imposed structural loads. Soil and rock formations have specific engineering properties which affect the supporting value and stability of the founding media and are influenced by the geological history of the formation.

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- B. Sub-surface exploration for foundation design should delineate the horizontal and vertical limits of the deposition and establish the engineering properties that will affect the foundation design. The location and depth of the borings are selected to accomplish this purpose. Test borings are normally spaced geometrically to provide one boring for each 6,000 to 10,000 square feet of area. Inconsistencies or non-uniform conditions require a much closer spacing. The borings should penetrate to a minimum depth of twice the width of the loaded area beneath the founding level.
- C. Spacing of borings, establishment of boring depth and selection of engineering tests are the responsibility of an experienced soils engineer with consultation of the A/E, structural engineer and Owner to obtain the necessary information at a minimum of cost.
- D. Procedure:
1. On or before the Pre-Design Conference, the Owner's Project Manager will forward the results of any sub-surface investigations performed at or in the vicinity of the site for A/E study.
 2. The A/E and its consultants will study preliminary information, and with the Owner's Project Manager will determine whether additional exploratory testing will be required, and to what extent. If so, the A/E will proceed to acquire testing information through a testing lab approved by Owner. Owner will pay for testing information not-to-exceed the agreed estimated cost.
 3. After the schematic phase has been approved, the A/E and its consultants, the Owner's Project Manager, and the soils testing engineer for the laboratory will determine, based on projected structural loading (supplied by the A/E), the scope of any additional sub-surface tests which may be required. The A/E will proceed to acquire testing information not to exceed the agreed estimated cost.
 4. Embankments and Fill Areas: The use of soil for engineering purposes such as compacted fill for the support of structural load, levees and berms, and slope improvement should be accomplished by using soil mechanics technology. The compaction of the soil should accomplish an improvement in the ability of the soil to withstand shearing stresses, prevent excessive settlement and minimize volume changes in the soil. The degree of compaction that more nearly satisfies the majority of these considerations shall be determined by an approved soils laboratory. The optimum degree of compaction that will accomplish the intended purpose is selected from the resulting test data.
 5. Pavement Design: The soil investigation for pavement design includes shallow (5 feet) undisturbed core borings spaced approximately every 200 feet along the proposed street or at approximately every 10,000 square feet for a parking area. Intermediate borings are drilled in those instances where inconsistencies are encountered. The engineering design of the pavement section utilizes the soil investigation data provided by the soils laboratory, an analysis of the available construction materials, and a study to determine the types of vehicles that will utilize the pavement and a projection of the number of wheel load applications anticipated during the design period. The A/E and its consultants are

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expected to design a pavement which will meet the desired performance level with a minimum of maintenance expenditure.

6. Concrete Materials: Unusual applications of concrete construction can be assisted by a pre-design material investigation. Unusual concrete application problems should be studied prior to design in order to resolve problems that are created by the uniqueness of design. Pre-design testing is extremely helpful in eliminating unnecessary expenses and potential construction problems.

PART 5 - CONSTRUCTION TESTING

5.01 CONCRETE

- A. All concrete tests performed in the laboratory and on the job site, the design of mixes, and the inspection of concrete production should be performed in accordance with the applicable ASTM and ACI standards. The technician should be properly trained and completely familiar with the standards for the Work he is performing.
- B. These standard methods have been proven to be satisfactory when conscientiously applied by the testing agency and cooperatively accepted by all parties concerned with the concrete construction Work.
- C. The prime purpose of concrete testing and inspection is to provide all parties with the pertinent information required for successfully accomplishing the Work. The testing agency must meet and comply with the requirements of ASTM E-329.

5.02 SOIL (EMBANKMENTS, FILL AND SUBGRADE)

- A. The testing for soil compaction during the construction of embankments, fills and subgrades for pavement is accomplished by frequent tests of the moisture and field density of the compacted material. The frequency of field density tests is approximately one for each 4,000 to 8,000 square feet in each lift in embankments and fills and one for each 300 linear feet of street. Fill areas with limited access to compaction equipment should be tested more frequently.
- B. A laboratory moisture-density curve is required for each of the materials to allow comparison with the field density in order to determine the percent of compaction obtained. Mixing of different materials during the excavation of fill material will also necessitate a moisture-density curve. Blends of materials should be frequently checked with a single compacted specimen to obtain the compacted weight of material for comparison with the available moisture-density curves. Each of the soils encountered in the project should be identified by liquid limit, plastic index and minus 20 mesh sieve tests.
- C. These identification test correlations should be accompanied by a description of the materials with respect to color, texture and soil type. The common method of identification and description is found in the unified system of soil classification. The degree of compaction required in the specifications should be established by a pre-design analysis of the soil. The

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field density tests are made to confirm compliance with the specification requirements. To be of value, the test results must be representative of an area that has been uniformly prepared.

5.03 BASE AND SUB-BASE PAVEMENTS

- A. Two types of tests are required in the construction of pavement sub-base and base layers. These are tests performed for acceptance of material sources and tests to verify construction procedures. The acceptable test may be duplicated during the progress of the Work when deemed necessary by the job inspector. Acceptance tests for the pavement sub-base and base materials normally include the Los Angeles abrasion of the aggregate, the gradation of the material and the plasticity index of the fines. The gradation of the material and the plasticity of the fines should be checked at frequent intervals during the construction to maintain the specified quality.
- B. The selection of quality standards for specifying materials should be done carefully to prevent the use of requirements that are uncommon in the area or that specify a quality which cannot be obtained within an economical distance. Texas Highway Department standards may prevail in one portion of the state and federal specifications might be the controlling factor in other parts of the state.
 1. A quality pavement can be obtained with either of the two standards, but the familiarity to the suppliers in the area is important in specifying a material that would be easily recognized. Equivalent pavement sections can be obtained with stabilization techniques that will improve the available materials to an economic advantage. These determinations should be made prior to the completion of the Construction Contract Documents and Specifications. The compaction of the material is checked by field density tests. These tests are made at a frequency of approximately one for each 4,000 to 8,000 square feet per 6-inch layer.
 2. The location of the field density tests should be subject to the direction of the job inspector. The tests should be representative of a uniformly compacted area. A sufficient number of moisture-density curves should be performed to establish the range of compacted material weight for computing the percent of compaction obtained by the Contractor.

5.04 STRUCTURAL METALS

- A. Welded connections:
 1. A procedure for satisfactorily welding the joint should be qualified prior to initiating any field welding. The qualification of an acceptable procedure should include the joint preparation; joint fit-up the type and size of the welding rod, the position of welding, methods to be used in cleaning the weld and the size and type of metal to be jointed by the weld. Sufficient tests should be performed on the joint welded by the proposed procedure until the procedure has proven to be satisfactory.
 2. In addition to qualifying the procedure for welding, each welder should be qualified by testing the specimens he prepares using the procedure qualified for the project. Qualified

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procedures and certified welders will indicate the availability of adequate methods or skills, but do not ensure the required performance.

3. Welding should be done under the observation of a qualified welding inspector. In addition, a sufficient number of radiographs or ultrasounds should be taken of in place welds to evaluate the performance of each welder.

B. Bolted Connections:

1. High strength bolted connections that depend on tightening of the bolts to a specific tension should be tightened by the "turn of the nut" method.

5.05 OTHER BUILDING MATERIALS

- A. There are other building materials that require testing on a Project. The design of masonry mortar mixes and the job testing of mortar using mortar cube testing and prism compression testing is recommended as a quality control method by our inspectors.
- B. Lightweight concrete masonry units and structural clay masonry products should be tested for absorption and compression. A performance requirement should be tested prior to final acceptance and payment.

PART 6 - COORDINATION OF DESIGN

- A. The Engineer shall coordinate Work with the Architect and the Mechanical and Electrical Engineers to avoid conflicts in dimensions and space requirements.
- B. Close attention should be given to mechanical requirements for construction clearances, openings, penetration of structural members, inertia pads, equipment weights, vibrations and special framing.
- C. The Engineer shall review architectural details to verify that lintels, shelf angles, handrail anchors, miscellaneous framing members, clip angles, anchors, bolts and welds have been properly sized and spaced for their required carrying capacity. Evaluate details for simplicity, economy, ease of erection and flexibility to meet construction tolerances. This review should be continuous as required during preparation of Construction Contract Documents.
- D. The architectural elevations shall clearly indicate the locations of all vertical and horizontal joints in all masonry. These joints shall be reviewed by the Structural Engineer.
- E. Any new openings or penetrations through existing structures shall be coordinated with all other design disciplines and shall be clearly shown in the Structural Drawings.

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PART 7 - DOCUMENT REVISION HISTORY

Issue	Date	Revision Description	Reviser
	01-01-07	Initial Adoption of Element	
Rev. 1	10-30-08	Added paragraph 1.01 H., requiring coordination of folding partitions, projection screens and high density filing systems.	LN
Rev. 2			
Rev. 3			
Rev. 4			
Rev. 5			

END OF ELEMENT Z2015