

SECTION 3 - FINAL DESIGN

1. Final Design Submittal. The Final Design submittal shall consist of the following documents:

- Design Analysis
- Drawings
- Typed Specifications
- Marked-up Guide Specifications
- Cost Estimate
- DD Form 1354 Data Sheet
- Completed Environmental Permit Matrix (if required by the scope of work)
- Final Engineering Considerations and Instructions for Field Personnel Report
- Other Items as Required by the Scope of Work

The designer must include the requirements of SECTIONS 1 and 2, of this guide, in the Final Design documents whether or not any previous submittals were required. This chapter will define, by discipline, requirements of the Design Analysis and the Drawings. The specific requirements for preparation of the Typed Specifications and Marked-up Guide Specifications are described in A-E Guide, Volume 3, Specifications. The specific requirements for the preparation of the Cost Estimate are contained in A-E Guide, Volume 2, Cost Estimating. A-E shall also refer to Chapter II, "Presentation of Data" of this guide for Design Analysis format and drawing format and quality requirements. See the appropriate appendix of this volume for Environmental Permit Matrix Plate 17, Chapter IV, and Engineering Considerations and Instructions for Field Personnel Report requirements. (Appendix B)

1.1. Objective. The final submittal represents 100% of the design effort and is intended to present a biddable, constructable and operable design package, conforming to all the appropriate criteria. Final design will be accomplished by developing and refining the design as presented in the previously prepared submittal(s) (Concept, Preliminary as applicable) and as modified by the review comments.

1.2. Changes to Basic Design. Major changes to the basic design will not be permitted at this time, unless these changes are the result of review comments, changes in

criteria, changes in scope of work, or unforeseen problems necessitating the A-E to alter his original design. All the changes shall be resolved through the COE PM before proceeding. If major changes have been made since the last submittal, such changes shall be identified and described in the Design Analysis.

- 1.3. Design Analysis - General Requirements. The Design Analysis, prepared for previous submittals, shall be expanded and refined into final form to contain that which was required by SECTIONS 1 and 2 of this chapter plus requirements contained herein.
- 1.4. Drawings - General Requirements. Expand and fully develop the drawings required by Sections 1 and 2 of this chapter adding new drawings as necessary to meet the requirements stated hereinafter. Include in the drawings, all plans, elevations, sections, wall penetrations, furred spaces, duct and pipe chases necessary for mechanical and electrical systems. Consider spacing of required off-sets of beams, girders, reinforcing steel, joists and truss members. Where space is tight, show unequivocally that the systems will fit in the space provided. Particular attention shall be paid to areas of duct branches and cross-overs. Close coordination between all designers shall be accomplished to avoid conflicts between the various disciplines* drawings. Whenever additive or deductive bid items are required, the limits of work or scope of these items shall be well defined on the respective disciplines* drawings and clearly defined by word description in the specifications. (See A-E Guide, Volume 3, Specifications, for bid schedules). Make sure adequate details are provided to cover those situations where additive bid items are not awarded such that the drawings present a complete design without the additive bid items.
- 1.5. Civil Design.
 - 1.5.1. Design Analysis - Narrative. Complete the discussion of civil features that was presented in the Concept and/or Preliminary submittals. Update the narrative to include any changes brought about as a result of review comments.

- 1.5.2. Design Analysis - Calculations. See Preliminary submittal requirements. Update the calculations to include any changes required by review comments.
- 1.5.3. Drawings. Expand and fully develop drawings used in Concept, and/or Preliminary submittals. Add any new sheets necessary to complete the presentation.
- 1.6. Landscaping Design.
 - 1.6.1. Design Analysis - Narrative. Complete the discussion of the landscape treatment that was presented in the Concept, and/or Preliminary submittals. Update the Design Analysis to include any changes brought about by review comments. If no landscaping is required, so state.
 - 1.6.2. Design Analysis - Calculations. Provide all calculations used for determining pipe sizes, type of sprinkler head in regards to area of coverage, and number of heads per valve. Define water pressure used in analysis and state how that value was determined:
 - 1.6.3. Drawings.
 - 1.6.3.1. Landscaping Plan. Show exact location of each plant, with a connecting line to plan symbol indicating type of plants and number of plants. Show exact location of construction features, i.e., benches, mowing strips, drainage ways, header boards, fences, retaining walls, garden structures, planters, pathways, walkways, service and refuse areas. These features are to be detailed on the landscaping plan sheets.
 - 1.6.3.2. Planting details and sections. Details and sections required to define the work are to be drawn to a scale of $\frac{1}{2}$ " = 1'-0" minimum or as approved by the COE.
 - 1.6.3.3. Planting schedule. Provide a plant schedule to include the following:
 - 1.6.3.3.1. Common name.
 - 1.6.3.3.2. Botanical name.

- 1.6.3.3.3. Quantity of each variety planted.
- 1.6.3.3.4. Height after planting.
- 1.6.3.3.5. Container size and kind of container space pattern. Tree size should be a minimum of 15 gallons to improve survivability.

1.6.3.4. Irrigation Plan. The irrigation plan shall be drawn on a separate sheet. Show all irrigation lines, spray heads, and drip emitters. Show coverage of each spray head on the drawing. Show pipe sizes, control valves, vacuum breakers and point of connection to water distribution system, including the dynamic head at the point of connection. Show mechanical appurtenances necessary for the proper function of the system. Each item will be indicated by an appropriate symbol. Indicate each kind and size of pipe by symbol. Provide a table indicating types of spray heads and drip emitters, diameter of coverage, gallons per minute (gpm) and minimum pounds per square inch (psi) required at each head. Indicate total water requirement and pressure required for the system.

1.6.3.5. Irrigation schedule. Provide an irrigation schedule to include the following:

- 1.6.3.5.1. Type and size of head, gpm, pressure in psi required and radius.
- 1.6.3.5.2. Type and size of drip emitter.
- 1.6.3.5.3. Type and size of valve.
- 1.6.3.5.4. Type of controller.
- 1.6.3.5.5. Type and size of pipe.
- 1.6.3.5.6. Type of backflow preventor.
- 1.6.3.5.7. Method of tap.

1.6.3.6. Irrigation Details. Other details shall be added as necessary to clearly show the work to be done. Irrigation details and sections are to be

drawn to a scale of $\frac{3}{4}$ " = 1'-0" minimum as approved by the COE.

1.7. Architectural Design.

1.7.1. Design Analysis - Narrative. Complete the discussion of architectural features presented in the Concept and/or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

1.7.2. Design Analysis - Calculations. Update the floor area calculations IAW Plate 18, Chapter IV, to reflect changes brought about by review comments and/or floor plan changes.

1.7.3. Drawings. Expand and fully develop drawings used in Concept, and/or Preliminary submittals. Add any new sheets necessary to complete the presentation, including the following:

1.7.3.1. Finish and colors: Complete for each space by use of "Finish Schedule, Finish Legend and Color Schemes" (see Plates 10, 11, 12, and 13, Chapter IV). Include color of factory finished materials (e.g., floor tile) for all interior finishes and for all building exterior finishes.

1.7.3.2. Door schedule: This shall follow sample format indicated on Plate 8, Chapter IV.

1.7.3.3. Window schedule: This shall follow sample format indicated on Plate 9, Chapter IV.

1.7.3.4. Roof clutter and the trade-off of cost versus acceptable aesthetics shall be discussed in the Design Analysis and at the Preliminary Review Conference. Concurrence of the user regarding acceptability of the roof aesthetics will be obtained and documented at the Preliminary Review Conference.

1.8. Structural Design.

1.8.1. Design Analysis - Narrative. Complete the discussion of structural features that was presented in the Concept and/or Preliminary submittals. Update

the narrative to include any changes brought about by review comments.

1.8.2. Design Analysis - Calculations. Present complete structural calculations covering all parts of the structure and miscellaneous facilities.

- 1.8.2.1. Design methods shall be described, including assumptions, theories, and technical formulas employed in design solutions.
- 1.8.2.2. Live loads shall be placed to produce maximum stresses and minimum stresses where there is a possibility of stress reversal.
- 1.8.2.3. If special methods of solution, tables, etc., are employed, references should be made in the calculations to the sources of such material.
- 1.8.2.4. For addition/alteration type projects, provide calculations necessary to verify adequacy of existing structure to support new functional loads or to satisfy any new loading criteria.
- 1.8.2.5. When a computer is utilized to perform design calculations, the analysis shall include copies of computer input data and output summaries presented in understandable language, accompanied by diagrams which identify joints, members, areas, etc., according to the notations used in the data listings. This will form an integral part of the Design Analysis in lieu of manual calculations otherwise required. A complete listing of all computer output will be provided, bound separately, when it is too voluminous for inclusion in the Design Analysis. These listings will be augmented by intermediate results where applicable, so that sufficient information is available to permit manual checks of final results. Include a sample hand calculation of each structural element (e.g., a truss) under one loading condition (i.e., usually the most critical) for each major system (e.g., lateral system, beam framing, etc.). This will facilitate reviewers who are not familiar with your particular program in spot checking the balance of the submitted computer data.

- 1.8.2.6. When submitting computer data, include one sample hand calculation of one item (e.g., a truss), under one loading condition (i.e., usually the most critical) for each major system (e.g., lateral system, beam framing, etc.). This aid will facilitate the speed of those reviewers not familiar with your particular program in spot checking the balance of the submitted computer data.
- 1.8.3. Drawings. Expand and fully develop drawings used in Concept and/or Preliminary submittals. Add any new sheets necessary to complete the presentation.
- 1.8.3.1. The structure should be carefully studied so that elaborate details are not required and all information necessary for construction is clearly and simply presented on the drawings. Typical sections shall be truly typical and not representative of one particular condition.
- 1.8.3.2. Wall Elevations: Wall elevations shall be provided for precast or tilt-up concrete panels, showing typical reinforcing, reinforcing around openings, connections, etc. The intent is to show one complete design on the drawings, even though manufacturers may prefer to detail things differently.
- 1.8.3.3. Joints: The location and details of all joints shall be shown on the drawings. Include control joints in slabs-on-grade, construction joints in walls, floors, roofs, and expansion and seismic joints.
- 1.8.3.4. Structural data: State the soil bearing values and other pertinent information from the Geotechnical Report, design live loads for various areas of the building; design wind load; seismic zone; 2, I, K, C, S values, whether or not the building has been designed for future horizontal or vertical loads; and any other notes necessary to clarify or complete the information shown on the drawing. The COE or A-E prepared Geotechnical Report shall not be referenced because it is not part of the contract documents. Check all general

structural notes for conflicts with the specifications. The notes should not repeat the specifications. All structural data shall appear on the first sheet of the structural drawings.

1.8.3.5. Stair Details Show all structural beams and connections that are shown supporting stairs usually detailed on the Architectural Drawings.

1.8.3.6. Roof Details.

1.8.3.6.1. Show all fastener details of roof deck to supporting members.

1.8.3.6.2. Show all roof framing connections, including RC and CHU beam seats, column connections, and beam-to-girder connections (as appropriate).

1.8.3.6.3. Show all details that provide slip joints for temperature changes and all details that transfer lateral loads to the vertical shear system.

1.8.3.6.4. Show all additional framing needed to provide for concentrated vertical loads, including both at and between node(s) of roof trusses.

1.8.3.6.5. On roofs where the deck is not used as a diaphragm, indicate crossbracing between all roof-framing members. Specifically on roof trusses, show cross bracing at 3'-0" maximum.

1.8.3.7. Composite construction and continuous framing. Where beam reactions are required on contract drawings for composite construction and continuous framing (as stipulated for Steel Framed Beam Connections in the AXSC Manual of Steel Construction), the A/E is not relieved from drawing completely all of the various beam-to-beam and beam-to-column connection details that normally would be drawn for any construction that is non-continuous, non-composite, or both under service load.

1.9. Mechanical Design.

1.9.1. Design Analysis - Narrative. Complete the discussion of Mechanical features that was presented in the Concept and/or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

1.9.2. Design Analysis - Calculations.

1.9.2.1. Finalize all calculations leading to sizing of distribution systems, selection of equipment, power requirements, controls, and selection of auxiliary equipment.

1.9.2.2. Equipment selection is restricted to regularly cataloged items of domestic manufacture, in commercial service for at least two (2) years prior to bid opening, and supplied by dealers having service organizations supporting the project location. Completely identify each piece of equipment with three manufacturers' names, model numbers, and characteristics. Do not indicate proprietary manufacturers' names and model numbers on the drawings or in the specifications. Provide catalog cuts of selected equipment.

1.9.2.3. Provide complete tabulation of cooling loads. Psychrometric charts for all the air handling systems with cooling are required.

1.9.2.4. Fire Pumps. If required fire pumps shall be sized per NFPA 20 Include catalog cuts and NFPA Handbook Section 16, Chapter 6. Indicate pump flow vs. pressure. Indicate combined (i.e., fire pump demand plus outside hydrant demand) to assure yard system pressure does not fall below 20 psig. Include catalog cuts and manufacturers published pump curve.

1.9.2.5. For projects being on shelf for one year or more, available fire water flow shall be verified a second time at the next submittal; the mechanical designer shall refer to base Fire Marshall to conduct one more flow test to be aware of all possible changes in water supply in this period of time.

1.9.3. Drawings. Expand and fully develop drawings used in Concept and/or Preliminary submittals. List room names and numbers on all plans and partial plans as shown on the architectural plans. Add any new sheets necessary to complete the presentation, including the following:

1.9.3.1. Plumbing. Provide the following:

1.9.3.1.1. Show water, waste and vent piping in two-dimensional riser diagrams for complicated plumbing systems, such as medical, dental facilities and others and for buildings two or more stories high.

1.9.3.1.2. Provide a schedule of plumbing fixtures and equipment. Coordinate schedule with Table I of Specification Sections CEGS-15400 or 15410.

1.9.3.2. Heating, Ventilating and Air Conditioning (HVAC). Provide the following:

1.9.3.2.1. Double line air distribution ducts will be required for all cross sections, elevations, and in mechanical rooms. Single line ducts may be used for air distribution layout, provided sufficient cross sections are shown for congested areas, and for areas that are subject to potential structural interference.

1.9.3.2.2. If required for clarification of duct sizes and duct runs, show single line riser diagrams for supply, return, and exhaust air systems in multi-story buildings. Provide sections where needed to show special relations and indicate the typical location of lights, structural members, etc.

1.9.3.2.3. Locate and detail all fire dampers.

1.9.3.2.4. Provide piping schematics to show all complicated flow processes.

1.9.3.2.5. Provide a sequence of operation and control, and control system schematic diagrams for each Mechanical System.

1.9.3.3. Fire Protection. Provide the following:

1.9.3.3.1. Minor fire protection work may be shown on the plumbing plan. Title block shall indicate that the drawing is for both plumbing and fire protection.

1.9.3.3.2. For detail of sprinkler riser, see COE Standard Mechanical Detail Drawings.

1.9.3.3.3. Identify all sprinkled areas. Use different identification (symbols) for areas with different density (type of hazard). List each symbol with its pertinent hazard and density in the legend and symbols.

1.9.3.3.4. Show the riser locations on the plans.

1.9.3.3.5. Do not show sprinkler system layout, i.e., location of mains, branches, and sprinkler heads.

1.9.3.3.6. For Hydraulically Calculated Sprinkler Systems, show the following information (see MIL-HDBK-1008A).

1.9.3.3.6.1. Type of hazard.

1.9.3.3.6.2. Minimum area of water demand.

1.9.3.3.6.3. Minimum rate of water application (density) GPM/sq. ft.

1.9.3.3.6.4. Any special sprinkler head temperature rating or classification.

1.9.3.3.6.5. Minimum hose stream requirements.

1.9.3.3.6.6. Fire Hydrant location and flow data including static and residual pressures (normally listed in design analysis and/or shown on Civil Drawings).

- 1.9.3.3.6.7. For projects with several sprinkled areas of different density, provide a table listing the miscellaneous areas, occupancy rating, density, area of demand, and hose stream requirements.
- 1.9.3.3.6.8. For warehouses (refer to NFPA 231 and NFPA 231C1, the following shall be shown on the drawings.
 - 1.9.3.3.6.8.1. commodity classification.
 - 1.9.3.3.6.8.2. pallet type.
 - 1.9.3.3.6.8.3. shelf type (open, slatted or solid).
 - 1.9.3.3.6.8.4. encapsulated or non-encapsulated.
 - 1.9.3.3.6.8.5. maximum storage height (not rack height).
 - 1.9.3.3.6.8.6. storage rack configuration (single, double or multiple row).
 - 1.9.3.3.6.8.7. whether sidewall sprinkler protection of columns is required.
 - 1.9.3.3.6.8.8. Whether in-rack sprinklers are required due to storage height in excess of 25-feet, encapsulation of pallets, or to minimize fire water requirements for storage height of less than 25-feet.
 - 1.9.3.3.6.8.9. whether in-rack sprinklers are required at one level, two levels or at every tier.
 - 1.9.3.3.6.8.10. in-rack sprinkler water demand
 - 1.9.3.3.6.8.11. ceiling sprinkler density (GPM/SF)

- 1.9.3.3.6.8.12. design area of sprinkler operation
- 1.9.3.3.6.8.13. ceiling sprinkler water demand
- 1.9.3.3.6.8.14. inside hose stream demand (minimum 100 GPM)
- 1.9.3.3.6.8.15. combined inside and outside hose demand (minimum 500 GPM)
- 1.9.3.3.6.8.16. duration of water supply required (see NFPA 231C)
- 1.9.3.3.6.8.17. fire protection riser location(s)
- 1.9.3.3.6.8.18. fire wall/partition locations
- 1.9.3.3.6.8.19. water flow available at base of riser (GPM flow rate and associated residual pressure)

1.9.3.4. .Energy Monitoring and Control Systems (EMCS).

- 1.9.3.4.1. The designer is required to coordinate selection of points to be monitored with the using agency.
- 1.9.3.4.2. Provide schematic diagrams and 1-0 summary as shown in TM5-815-2.
- 1.9.3.4.3. The EMCS schematic diagrams shall be separate from the control system diagrams as described above in Subparagraph 3.9.3.2.5.

1.10. Electrical Design.

- 1.10.1. Design Analysis - Narrative. Complete the discussion of electrical features that was presented in the Concept and/or Preliminary submittals. Update the narrative to include any changes brought about by review comments.

- 1.10.1.1. Describe any special switching or dimming systems required for any area.
- 1.10.1.2. Provide rationale for selection of reduced-voltage starting equipment.
- 1.10.1.3. Provide an energy impact analysis.
- 1.10.2. Design Analysis - Calculations.
 - 1.10.2.1. Provide complete design calculations for all interior and exterior electrical systems.
 - 1.10.2.2. Provide manufacturers' names and model numbers for each major piece of equipment used in determining dimensional and weight requirements. Do not use proprietary names and model numbers on the drawings or in the specifications. See Chapter 1, Paragraph 7.0, and A-E Guide, Volume 3, Specifications.
 - 1.10.2.3. Calculations for the maintained foot-candle intensities in all areas shall be shown.
 - 1.10.2.4. Provide calculations for sizing transformer(s) and short-circuit interrupting capacity.
 - 1.10.2.5. Voltage drop on all service and feeder circuits, and a worst-case branch circuit.
 - 1.10.2.6. Additional calculations as required to supplement the designs.
 - 1.10.2.7. For presentation of computer data, see structural computations final submittal.
- 1.10.3. Drawings. Expand and fully develop drawings used in Concept and/or Preliminary submittals adding new sheets as necessary to meet minimum requirements stated hereafter. Concept drawings may be used in this expansion to finals, if applicable. Show in plan, necessary elevations and sections, all wall penetrations, furred spaces, duct and pipe chases necessary for mechanical and electrical systems. Consider spacing or required off-sets of beams, girders, reinforcing steel, joists and truss members.

Where space is tight, show unequivocally that the above systems will fit the space provided. Particular attention should be paid to areas of duct branches and cross-overs. Close liaison between all designers is necessary here to avoid conflicts in the drawings. Whenever additive or deductive bid items are required, the limits of work or scope shall be well defined on the drawings for the respective disciplines unless clearly defined by description in the specifications (See A-E Guide, Volume 3, Specifications, for Bid Schedules).

- 1.10.3.1. Outside distribution system. Provide the following:
 - 1.10.3.1.1. Overhead: Show location of new and existing poles, and routing of new lines on an electrical-only site plan. Indicate type and size of existing overhead conductors.
 - 1.10.3.1.2. Underground: Show location of new and existing manholes and handholes on an electrical-only site plan. Locate and show details of major equipment. Show routing of ductline, ductline sections and detail of pole riser. Show adequate detail for complex grounding system (if applicable).
 - 1.10.3.1.3. 3 Area lighting: Show location of street, parking and walkway lighting poles. Provide details of luminaires, poles and bases. Details of luminaires shall only be provided when not covered by COE Standard Drawing No. 40-06-04.
 - 1.10.3.1.4. Floodlighting (on Poles): Provide layout of lighting poles, showing dimensions and aiming angles.
 - 1.10.3.1.5. Distribution System Profiles. For overhead and/or underground distribution projects over 2,000 linear feet in total length, profiles shall be furnished as described under Civil Design.

1.10.3.1.6. Telephone Service Connection. Show the exterior telephone service point of connection.

1.10.3.2. Interior distribution system. Provide the following:

1.10.3.2.1. Floor Plan. Define the physical limits of each hazardous area and the class, division and group of equipment and wiring. Show conduit seals IAW NEC Article 500. Show sizes of all conduits including conduit to be wired by others. Indicate number and size of conductors based on copper conductors. See Guide Specification CEGS-16415 for aluminum conductor options. Provide a numbering system for all circuits. Detail seismic restraints for all electrical equipment. Show complete fixture, switch, and receptacle arrangement, fixture details and identification of fixture type, special control equipment diagrams and complex switching diagrams. Indicate energy saving fluorescent fixtures with matched ballast and lamps. Provide fire rated recessed fluorescent fixtures to match fire rating of ceiling.

1.10.3.2.2. Electrical Equipment. For all electrical equipment, list the performance characteristics required, complete schematic diagrams, and a written description of operation of complex control systems.

1.10.3.2.3. Panel Schedules. For panelboards, switchboards, power switchgear assemblies and motor control centers, provide total connected load, total spare load, main and branch circuit ratings, interrupting ratings, frame sizes for each circuit, number of poles, and description of each load.

1.10.3.2.4. Wiring Diagrams. Show a wiring diagram for each of the following systems on the plans: telephone, television, fire alarm, intercommunication, public address, and other required special systems. Show locations only

of all antennas, service entrances, outlets and major equipment on a floor plan.

- 1.10.3.2.5. Airfield Lighting. Where airfield lighting is included in the project, show location, controlling dimensions, extent of the proposed system, routing of supply circuits, location of vaults and control towers, and locations for various types of lighting units.
- 1.10.3.2.6. Cathodic Protection. Where a cathodic protection system is included, show extent of the facilities to be protected, location and type of anode beds, location of test points, details for sectionalizing bonding and insulating (where applicable) an underground piping system, and source and routing of supply for impressed current.
- 1.10.3.2.7. Generating Plant. If the project includes a generating plant, provide a one line wiring diagram, fuel oil and coolant piping diagrams, equipment details and layout, and transfer controls in block form.