KLM Technology Group
#03-12 Block Aronia,
Jalan Sri Perkasa 2
Taman Tampoi Utama
81200 Johor Bahru
Malaysia

CIVIL AND STRUCTURAL ENGINEERING DESIGN CRITERIA

(PROJECT STANDARDS AND SPECIFICATIONS)

TABLE OF CONTENT

SCOPE

This Project Standard and Specification summarizes the codes and standards and standard design criteria and practices that will be used during the project engineering, design and construction. These criteria form the basis of the design for the structural components and systems for the project. More specific design information will be developed during the detailed design phase to support equipment procurement and construction specifications.

Prior to the start of any increment of construction, the proposed lateral-force procedures for project structures and the applicable designs, plans and drawings for project structures will be submitted for approval.
Proposed lateral-force procedures, designs, plans, and drawings shall be those for:

- Major project structures
- Major foundations, equipment supports, and anchorage
- Large, field-fabricated tanks
- Switchyard structures

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. American National Standards Institute (ANSI)
2. Asphalt Institute (AI)
3. Department of Transportation
4. Concrete Reinforcing Steel Institute (CRSI)
5. Factory Mutual (FM)
6. National Association for Corrosion Engineers (NACE)
7. Plumbing Code
8. Building Code

9. Applied Technology Council, "Tentative Provision for the Development of Seismic Regulations for Buildings," (ATC-3-06).
10. American Institute of Steel Construction (AISC).
    - S335 - "Specification for Structural Steel Buildings - Allowable Stress Design and commentary."
    - S303 - "Code of Standard Practice for Steel Buildings and Bridges."
    - S329 - "Allowable Stress Design Specifications for Structural joints using ASTM A325 or A490 Bolts."
    - M016 - "Manual of Steel Construction Allowable Stress Design."
11. American Iron and Steel Institute (AISI) "Specification for the Design of Cold-Formed Steel Structural Members," Edition Cold-Formed Steel Design Manual Parts I-VII.
12. American Welding Society (AWS)
    - D1.1—Structural Welding Code—Steel
    - D1.3—Structural Welding Code—Sheet Steel
13. American Concrete Institute (ACI)
    - ACI 318/318R "Building Code Requirements for Structural Concrete (ACI 318) and commentary (ACI 318R)."
    - ACI 318.1 and Commentary - ACI 318.IR.
    - ACI 530 "Building Code Requirements for Concrete Masonry Structures and Commentary (ASCE 5) (TN4S 402)."
    - ACI 212.3R "Chemical Admixtures for Concrete."
    - ACI 302.IR "Guide for Concrete Floor and Slab Construction."
    - ACI 35OR "Environmental Engineering Concrete Structures."
14. Structural and Miscellaneous Steel.
    - ASTM A569/A569M - Standard Specifications for Steel Carbon (0.15 m maximum percent) Hot-Rolled Sheet and Strip, Commercial Quality.
    - American Society for Testing and Materials (ASTM). The following codes and standards shall be included as a minimum
    - ASTM A36/A36M "Standard Specification for Structural Steel."
    - ASTM A992 Specification for Structural Steel.
    - ASTM A53 "Standard Specification for Pipe, Steel Black and Hot-Dipped, Zinc Coated, Welded and Seamless."
    - ASTM A276 "Standard Specification for Stainless and Heat Resisting Steel Bars and Shapes."

- ASTM A500 "Standard Specification for Cold-forced Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes."
- ASTM A695 "Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel."
- ASTM A307 "Standard Specification for Carbon Steel Bolts and Studs."
- ASTM A153/Al53 "Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware."
- ASTM A182 "Standard Specification for Steel Wire, Plain, for Concrete Reinforcement."
- ASTM A185 "Standard Specification for Welded Steel Wire Fabric, Plain, for Concrete Reinforcement."
- ASTM A615/A615 "Standard Specification Deformed and Plain Billet-Steel Bars for Concrete Reinforcement."
- ASTM A-706-60 Specification for Reinforcing Steel Bars in Concrete.
- Masonry Institute of America, "Reinforced Masonry Engineering Handbook."
- American Water Works Association (AWWA).
- AWWA D100 "Welded Steel Tanks for Water Storage, (AWS D5.2).
- "Addendum D100A (AWS D5.2-84A)."
- AWWA C301 "Prestressed Concrete Pressure Pipe, Steel Cylinder Type for Water and Other Liquids."
- AWWA C302 "Standards for Reinforced Concrete Water Pipe Noncylinder Type, Not Prestressed."

15. American Association of State Highway and Transportation Officials. (AASHTO) (GDHS-2), "A Policy on Geometric Design of Highways and Streets."
16. National Fire Protection Association Standards (NFPA).
    - NFPA 850 Fire Protection for Electric Generating Plants.
17. Steel Structures Painting Council Standards (SSPC).
18. American Society of Nondestructive Testing (ASNT-TC-lA).
19. American Society of Civil Engineers (ASCE):
    - ASCE 7-98, Minimum Design Loads for Buildings and Other Structures
20. Code of Federal Regulations, Title 29—Labor, Chapter XVII, Occupational Safety and Health Administration (OSHA).
    - Part 1910—Occupational Safety and Health Standards.
    - Part 1926—Construction Safety and Health Regulations

21. National Association of Architectural Metal Manufacturers (NAAMM)—Metal Bar Grating Manual.
22. Hoist Manufacturers Institute (HMI), Standard Specifications for Electric Wire Rope Hoists (HMI 100).
23. National Electric Safety Code (NESC), C2-1993
24. OSHA Williams-Steiger Occupational Safety and Health Act of 1970.
25. Steel Deck Institute (SDI)—Design Manual for Floor Decks and Roof Decks.

CIVIL DESIGN CRITERIA

Geotechnical Investigation

General

Geotechnical exploration, testing, and analysis will establish parameters required in the engineering of foundations. Criteria will be established to permit the most economical design that is compatible with life expectancy and service of structures.

Design Loads

Design loads for all structures will be determined in accordance with the criteria described below, unless the applicable building code requirements are more stringent.

Wheeled Crawler Loads

Loads exerted on roadway pavements, buried piping, box culverts, and embankments will be reviewed and selected prior to design of the underlying items. Typically, HS20 loads will be used for the design of roadway sub grade. Equipment loading such as scrapers (loaded), crawler cranes, and equipment transport trailers could exceed the typical HS20 loadings. Such loads will be considered where appropriate.

Site

1. Site Arrangement

   The site arrangement will conform to applicable laws, regulations, and environmental standards. The principle elements in the selection of site arrangement criteria are the physical space requirements and relationships dictated by each of the major systems. Distances between various systems will be minimized for economy. Utility interconnections will be optimized as

much as practical. Spill containment measures will be provided. Treatment systems will be provided for facility wastewater streams, if required, before discharge. Sanitary wastewater will be discharged to an on-site leaching field.
Internal access roads will be provided. The site arrangement will be developed to minimize fill and/or excavation costs while maintaining efficiency of project construction, operation, and maintenance. The Site Grading and Drainage Plan will use a series of on-site localized infiltration areas. Sheet flow, which follows the existing natural drainage course, will direct the runoff across the site to the localized infiltration areas incorporated into the Site Grading and Drainage Plans. The use of low runoff velocities and infiltration areas will allow the runoff to be absorbed into the ground. Wastewater that may contain oil will be routed through an oil-water separator.
The following criteria will be followed regarding site infrastructure:

- Oil and chemical storage areas will be designed to contain spills.
- Culverts and sanitary sewer manholes will be installed as required.
- Locations and requirements for fencing or walls will conform to applicable Building Codes and County Ordinances.

2. Grading and Drainage

The site grading and drainage system will be designed to comply with all applicable federal, state, and local regulations. The general site grading will establish a working surface for construction and operating areas, provide positive drainage from buildings and structures, and provide adequate soil coverage for underground utilities.
On-site drainage will be accomplished through gravity flow whenever possible. The surface drainage system will consist of gentle slopes. The buildings and structures will be located with the ground floor elevation a minimum of six inches above the finished grade. The preferred slope of the graded areas away from structures will be 1 percent with a minimum slope of 0.5 percent.
Site drainage facilities will be designed for the flow resulting from a 50-year, 24-hour rainfall. Temporary facilities will generally be designed for a 2-year rainfall. Any facilities located within a flood plain will be elevated and designed to prevent flooding of permanent facilities.
Runoff from possible oil and chemical contamination areas, such as the transformer areas and chemical storage and handling areas, will be contained. Storm water contained in these areas will be routed through an oil/water separator. Discharge form the oil/water separator will be monitored and discharged to the local area for absorption into the ground. Oil will be collected by a certified hauler and taken off site for disposal.

a. Excavation and Fill

   Excavation and fill will be balanced to the maximum extent possible.

   - Excavation : In areas requiring excavation, earth material will be removed to the required lines and grades. Any undesirable material will be removed and disposed of in accordance with applicable regulations. The remaining in-situ material will be graded and compacted to the depth and density determined by detailed design. Excavated material that meets the design requirements will be used as general site fill where possible.
   - Fill : Compacted fill material will be obtained from on site excavations to the maximum extent possible. The material will be placed and compacted to the grades and density determined by the design. Based upon the site geotechnical investigation findings, compaction will be provided under and within five feet of the foundation footprint. Open areas not supporting reflector foundations will be scarified and graded to achieve high soil permeability. Approximately six inches of topsoil will be placed on fill in any areas that are to be seeded or otherwise landscaped.

b. Drainage Swales

   Drainage swales will be designed to provide slow flow velocities and to accommodate expected site runoff as well as direct and control runoff from adjoining properties.

c. Storm water Drainage

   A storm water drainage system will be developed. Drainage swales will be used along the perimeter of the Solar Farm to control and direct storm water runoff for absorption into the ground as well as direct runoff into the existing area drainage course. In addition, multiple infiltration areas will be incorporated into the solar field grading plan to provide adequate short term residence time to allow the runoff to be absorbed into the ground.

d. Pre- and Post-Development Runoff Conditions

   The peak flow associated with the 50-year storm event at the site, before modifications (predevelopment), will be compared to the after-construction (post-development) conditions. It is anticipated that the post development runoff will not exceed the pre-development runoff condition.

e. Erosion and Sedimentation Control

   Erosion and sedimentation control will be provided to retain sediment on-site and to prevent violations of water quality standards.

The proposed site development will slightly alter the land areas of the site. Existing, sparse vegetation will be removed as required during site preparation. The general preparation of the overall site will be followed by earthmoving activities. Final finish grading will begin when all other grading operations are complete. Final grading may include seeding disturbed areas, surfaced with concrete, asphalt, or crushed aggregate or provided with a soil treatment design to limit the growth of grass and weeds.

Temporary erosion and sedimentation control measures used during construction will be designed to prevent sediments from being displaced and carried off-site by storm water runoff.

Prior to beginning excavation activities, a silt fence or straw bales will be installed along the perimeter of the project work areas where runoff to off-site areas could occur. The silt fence will filter sediments from construction runoff. During construction, the extent of earth disturbances will be minimized as much as practical.

Diversion ditches and/or berms will be constructed as necessary to divert runoff from off-site areas around the construction site. Temporary control measures will be maintained as necessary throughout the construction period.

Permanent erosion and sedimentation control measures within the project site will include the runoff collection system and infiltration system, surfaced traffic and work areas, and seeded non-working areas. These measures will minimize the possibility of any appreciable erosion of the resulting sedimentation occurring on the project site.

3. Traffic and Transportation

   Access to the Solar Farm will be provided by existing roadways. All roads will be appropriately surfaced during the construction period. Periodic watering or applications of a dust palliative material will be used to minimize dust problems.
   The minimum radius to the inside edge of pavement (EOP) or aggregate surface at intersections of the road will be 20 feet.

4. Fencing and Security

   Security and visual screening fencing will be provided around the Solar Farm. Access to the Solar Farm will be provided through a controlled access gate. Fencing heights will be in accordance with applicable codes, regulatory requirements and visual considerations.

5. Landscape Plan

The landscaping plan for the site shall be performed as follows:

- The landscape plan will rely on site topography, concentrating on those viewpoints that are likely to be visible to the general public.
- All landscape material used on the project will be selected with due consideration for the climatic and soil conditions on the site. The theme for the planting plan will be derived from an assessment of naturally occurring plant materials and an evaluation of the need for dense, hardy screening.

6. Sanitary Waste System

   Sanitary wastes will be conveyed to an on-site leaching field.

7. Geotechnical Investigation

   A Geotechnical Engineering Investigation for the project will be conducted during the early stages of engineering.

STRUCTURAL DESIGN CRITERIA

Datum

Site topographic elevations will be based on an elevation survey conducted using known elevation benchmarks.

Frost Penetration

The site is located in an area free of frost penetration. Bottom elevation of all foundations for structures and equipment, however, will be maintained at a minimum of 12 inches below the finished grade.

Temperatures

The design basis temperatures for civil and structural engineering systems will be as follows:

- Maximum 105°F
- Minimum 30°F

Design Loads

1. General

   Design loads for structures and foundations will comply with all applicable building code requirements.

2. Dead Loads

   Dead loads will consist of the weights of structure and all equipment of a permanent or semi-permanent nature including tanks, bins, wall panels, partitions, roofing, drains, piping, cable trays, bus ducts, and the contents of tanks and bins measured at full operating capacity. The contents of the tanks and bins, however, will not be considered as effective in resisting structure uplift due to wind forces; but will be considered as effective for seismic forces.

3. Live Loads

   Live load will consist of uniform floor live loads and equipment live loads. Uniform live loads are assumed equivalent unit loads that are considered sufficient to provide for movable and transitory loads, such as the weights of people, portable equipment and tools, small equipment or parts, which may be moved over or placed on the floors during maintenance operations, and planking. The uniform live loads will not be applied to floor areas that will be permanently occupied by equipment.
   Equipment live loads are calculated loads based upon the actual weight and size of the equipment and parts to be placed on floors during dismantling and maintenance or to be temporarily placed on or moved over floors during installation.
   Lateral earth pressures, hydrostatic pressures, and wheel loads from trucks, will be considered as live loads.
   Uniform live loads will be in accordance with ASCE Standard 7, but will not be less than the following:

   - Roofs 20 pounds per square foot (psf)
   - Floors and Platforms
     (steel grating and checkered plates) 100 psf

   In addition, a uniform load of 50 psf will be used to account for piping and cable trays, except that where the piping and cable loads exceed 50 psf, the actual loads will be used.
   Furthermore, a concentrated load of 5 kips will be applied concurrently to the supporting beams of the floors to maximize stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

   - Floors (elevated concrete floors) 100 psf

In addition, elevated concrete slabs will be designed to support an alternate concentrated load of 2 kips in lieu of the uniform loads, whichever governs. The concentrated load will be treated as a uniformly distributed load acting over an area of 2.5 square feet, and will be located in a manner to produce the maximum stress conditions in the slabs.

- Control Room Floor 150 psf
- Stairs, Landings, and Walkways 100 psf

In addition, a concentrated load of 2 kips will be applied concurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

- Pipe Racks 50 psf

Where the piping and cable tray loads exceed the design uniform load, the actual loads will be used. In addition, a concentrated load of 8 kips will be applied concurrently to the supporting beams for the walkways to maximize the stresses in the members, but the reactions from the concentrated loads will not be carried to the columns.

- Hand Railings

Hand railings will be designed for either a uniform horizontal force of 50 pounds per linear foot (plf) applied simultaneously with a 100 plf uniform vertical live load, or a 200-pound concentrated load applied at any point and in any direction, whichever governs.

- Slabs on Grade 250 psf
- Truck Loading Surcharge Adjacent to Structures 250 psf
- Truck Support Structures AASHTO-HS-20-44
- Special Loading Conditions Actual loadings

Laydown loads from equipment components during maintenance and floor areas where trucks, forklifts or other transports have access, will be considered in the design of live loads.

Pipe hanger loads for the major piping systems will be specifically determined and located. Piping expansion and dynamic loads will be considered on an individual basis for their effect on the structural systems. Loads imposed on perimeter beams around pipe chase areas will also be considered on an individual basis.

Pipe loads for other areas will be treated as uniform loads per unit floor area, and will be carried to the columns and foundations as dead loads. Pipe loads will not be considered as reliable dead load for uplift.

Equipment loads will be specifically determined and located. For major equipment, structural members and bases will be specifically located and designed to carry the equipment load into the structural system. For equipment weighing less than the uniform live load, the structural system will be designed for the live load.
The Steam turbine support systems will be designed for the following loads:

- Deadloads
- Live loads
- Normal torque loads (turbine)
- Temperature and pressure loads
- Seismic loads
- Emergency loads, such as turbine accident loads, and any temperature and pressure loads present during the emergency

4. Earth Pressures

   Earth pressures will be in accordance with the recommendations contained in the project-specific geotechnical report.

5. Groundwater Pressures

   Hydrostatic pressures due to groundwater or temporary water loads will be considered.

6. Wind Loads

   The wind forces will be calculated with a basic wind speed of 80 miles per hour (mph) and an exposure category of ‘C.’
   The overturning moment calculated from wind pressure shall not exceed two-thirds of the dead load resisting moment. The uplift forces calculated from the wind load pressure shall not exceed two-thirds of the resisting dead load. For determining stresses, all vertical design loads, except roof live loads, shall be considered to act simultaneously with the wind pressure.

7. Seismic Loads

   Structures will be designed and constructed to resist the effects of earthquake loads. The site is located on seismic zone 4. The occupancy category of the structure is 3 (Special Occupancy Structure) and corresponding importance factor (I) is 1.0. Other seismic parameters will be obtained from the geotechnical report.

8. Snow Loads

   Snow loads will not be considered.

9. Engine-Generator Loads

   The engine-generator loads for foundation design will be furnished by the equipment manufacturers, and will be applied in accordance with the equipment manufacturer's specifications, criteria, and recommendations.

10. Construction Loads

    The integrity of the structures will be maintained without use of temporary framing struts or ties and cable bracing insofar as possible. However, construction or crane access considerations may dictate the use of temporary structural systems.

11. Load Combinations

    At a minimum, the following load combinations will be considered. Applicable code prescribed load combinations will also be considered.

    - Dead load
    - Dead load plus live load plus all loads associated with normal operation of the equipment (e.g., temperature and pressure loads, piping loads, normal torque loads, impact loads, etc.)
    - Dead load plus live load plus all loads associated with normal operation plus wind load
    - Dead load plus live load plus all loads associated with normal operation plus seismic load
    - Dead load plus construction loads
    - Dead load plus live load plus emergency loads
    - Dead load plus wind load
    - Dead load plus seismic load

    Every building component shall be provided with the strength adequate to resist the most critical effect resulting from the following combination of loads.

    - Dead plus floor live plus roof live
    - Dead plus floor live plus wind
    - Dead plus floor live plus seismic
    - Dead plus floor live plus wind plus roof live / 2
    - Dead plus floor live plus roof live plus wind / 2
    - Dead plus floor live plus roof live plus seismic.

12. Special Considerations for Steel Stacks

    Steel stacks will be designed to withstand the normal and abnormal operating conditions in combination with wind loads and seismic loads, and will include

the along-wind and across-wind effects on the stacks. The design will meet the requirements of ASME/ANSI STS-1-1992, "Steel Stacks," using allowable stress design method, except that increased allowable stress for wind loads as permitted by AISC will not be used.

13. Special Considerations for Structures and Loads during Construction

For temporary structures, or permanent structures left temporarily incomplete to facilitate equipment installations, or temporary loads imposed on permanent structures during construction, the allowable stresses may be increased by 33 percent.
Structural backfill may be placed against walls, retaining walls, and similar structures when the concrete strength attains 80 percent of the design compressive strength (f'c), as determined by sample cylinder tests. Restrictions on structural backfill, if any, will be shown on the engineering design drawings.
Design restrictions imposed on construction shoring removal that are different from normal practices recommended by the ACI Codes will be shown on engineering design drawings.
Metal decking used as forms for elevated concrete slabs will be evaluated to adequately support the weight of concrete plus a uniform construction load of 50 psf, without increase in allowable stresses.

14. Allowable Stresses

Each load combination shall not exceed the allowable stress permitted by the appropriate code for that combination.

a. Concrete Structures

The required strength (U) shall be at least equal to the following:

- U = 1.4 Dead + 1.7 Live
- U = 0.75 (1.4 Dead + 1.7 Live + 1.7 Wind)
- U = 0.9 Dead + 1.3 Wind
- U = 1.4 (Dead + Live + Seismic)
- U = 0.9 Dead + 1.43 Seismic
- U = 1.4 Dead + 1.7 Live + 1.7 Earth Pressure
- U = 0.9 Dead + 1.7 Earth Pressure

b. Steel Structures

The required strength (S) based on the elastic design methods and the allowable stresses (Fs) defined in Part 1 of the AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings is as follows:

- S = Dead = 1.0 Fs
- S = Dead + Wind = 1.33 Fs
- S = Dead + Seismic = 1.33 Fs
- S = Dead + Live = 1.0 Fs
- S = Dead + Live + Wind = 1.33 Fs
- S = Dead + Live + Seismic = 1.33 Fs

The Strength LRFD (load and resistance factor design) approach may be used as allowed by Code.

Architecture

1. Architecture - Engineered Buildings

   General design criteria for materials and installation of architectural systems or components will be as follows:

   a. Exterior Walls

      These will be metal wall panel systems of the factory assembled or field erected type with exposed fasteners and minimum thickness of exterior sheet of 24 gauge galvanized steel.

   b. Installed Walls

      Installed walls will be watertight and will provide a “U” factor. Sound attenuation will be provided for sound absorption on walls enclosing equipment as required.

   c. Interior Walls

      Where durability is required, interior walls may be constructed of concrete block masonry, structurally designed and reinforced as required. In offices, shops, etc., metal studs with gypsum board will usually be used to form interior partitions. Insulation for sound control will be used where required by design.

   d. Fire Exits

      Fire exits will be provided at outside walls as required by code. Exit signs will be provided. Fire doors will bear an Underwriters Laboratory (UL) certification level for class of opening and rating for door, frame, and hardware. Doors will conform to hollow metal door requirements and have fillers adequate to meet the fire rating.

   e. Large Access Exterior Doors

      Large access exterior doors will be rolling steel type with weather seals and windlocks. Components will be formed from galvanized steel, factory