

Engineering Standard

SAES-A-204

31 May, 2004

Preparation of Structural Calculations

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Saudi Aramco DeskTop Standards

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1 Scope

This Standard covers mandatory requirements governing the preparation of structural calculations for the design of all industrial and miscellaneous steel, concrete, masonry, and precast concrete structures including equipment foundations, buildings, communication towers and offshore structures. Structural calculations are not required for ladders, handrail or other standard industry designs.

2 Conflicts and Deviations

- 2.1 Any conflicts between this Standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs) or industry standards, codes and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department, Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this Standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department, Saudi Aramco, Dhahran.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

[SAEP-103](#)

Metric Units of Weight & Measures

[SAEP-302](#)

Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement

Saudi Aramco Engineering Standard

[SAES-A-112](#)

Meteorological & Seismic Design Data

3.2 Industry Codes and Standards

American Institute of Steel Construction

AISC

Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings

American Concrete Institute

ACI 318

*Building Code Requirements for Reinforced
Concrete*

4 Purpose of Calculations

The purpose of calculations is as follows:

- a) To enable the designer to arrive at designs which are safe, feasible and economical.
- b) To provide a record for possible future reference.
- c) To satisfy code and/or Saudi Aramco requirements as to the adequacy of the design.
- d) To facilitate determination of the effects of possible future modifications.

5 Units

All calculations shall be done using the SI metric units as specified in [SAEP-103](#), "Metric Units of Weight and Measure", except when calculations are made in compliance with a Code, or using a computer program, which has not yet been metricated, the conventional units may be used. The end results of conventional calculations shall be converted to metric units.

6 Symbols

Symbols used for steelwork design shall have the same connotation as in the AISC Manual of Steel Construction; those for concrete design as in the ACI 318 Code. Other symbols shall conform to the corresponding international codes and standards that are referenced in the applicable Saudi Aramco Standard.

The connotation of all symbols in general used throughout the calculations shall be stated at the beginning of the calculations.

The connotation of symbols used only locally shall be stated immediately before or after the equations in which they are used.

7 Equations

All equations, graphs, nomographs, etc. used in the calculations shall be:

- a) Derived in the calculations, or
 - b) Referred to in the relevant standard, giving clause number, or
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- c) If taken from a textbook, accompanied by a copy of the pertinent page(s).
- d) Commonly used and easily recognized equations such as $PL/4$, $WL^2/8$, etc., need not be derived or have references provided.

8 Assumptions

Assumptions on which calculations are based shall be listed in an orderly manner. Each assumption supporting the calculations shall be clearly described and a sound basis (such as historical data) provided for it.

The calculations shall provide a brief statement describing the general design philosophy used in the design including the design concept adopted.

9 Parameters

The values of all parameters shall be stated at the beginning of the calculations. Justification is not required for commonly accepted values, e.g., Young's modulus, Poisson's ratio, coefficients of expansion, etc. However, all other parameters shall be justified, either by quoting a source (e.g., soils report or study) or by brief reasoning or reference to a standard or code. This applies in particular to the following:

- a) Temperature differentials
- b) Allowable ground bearing pressures, settlements and differential settlements
- c) Wind pressures, shall be calculated based on the appropriate basic wind speed and exposure factor defined in [SAES-A-112](#). The calculations shall state basic wind speed together with height, shape, gust and importance factors used.

10 General Presentation

The calculation presentation shall be in accordance with the following procedures and requirements:

10.1 Headings

The headings shall provide the following information:

- a) Saudi Aramco Budget Item, Engineering Work Order or Study number.
 - b) The name of the originator of the calculations and the name of the checker.
 - c) The title, which shall clearly describe the contents of the calculations.
 - d) The date the calculations were made.
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- 10.2 The cover sheet of each calculation package shall be properly labeled to identify the calculations for a particular Job Order, Engineering Work Order of Study item and for inclusion in Saudi Aramco permanent records. Individual calculation sheets following the cover sheet shall be consecutively numbered (1, 2, 3, etc.).
 - 10.3 Calculation packages shall include a Table of Contents and a listing of all codes and references used. The cut-off date of the reference Saudi Aramco Standard used during the design shall be indicated.
 - 10.4 All calculations shall be checked and initialed by a competent checker before being sent to the responsible Project Manager or Engineer. The designated checker shall perform a number-by-number check of the calculations and verify that all data used and results arrived at are correct before signing the calculations.
 - 10.5 Calculations are to be in the English language throughout.
 - 10.6 Structural calculations shall include design criteria, all primary load conditions, critical service load combinations and critical factored load combinations to be considered in the design. The structural design criteria must be tailored to the project at hand.
 - 10.7 Calculations shall have sufficient number of sub-headings to indicate clearly what is being calculated or designed. Both sub-headings and final answers shall be underlined for easy identification.
 - 10.8 Sufficient explanation shall be given so that calculation methods are easily understood. Simple clear sketches should be liberally used. Calculations shall be accompanied by sketches, such as Plans (at each level), Elevations, and Sections as required. Plan layout shall label beams such as B1, B2, G1, G2, etc., to identify beams or girders being designed.
 - 10.9 Structural calculations shall be complete with the required details including moment connections and special connections.
 - 10.10 Calculation packages should be limited to pertinent information, voided calculation sheets shall be removed if these sheets do not contain useful information.
 - 10.11 Calculations which are not clear and complete will not be accepted by Saudi Aramco.
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11 Computer Calculations

Computer calculations shall be in accordance with the following guidelines:

- 11.1 All computer models shall be accompanied by sketches that show joint and member numbers, support conditions and loadings.
- 11.2 Computer output must be accompanied by the corresponding input. Data provided as computer input shall be clearly distinguished from those computed in the program. The first sheet of each computer run shall be signed by the engineer responsible for the structural design. A program description (User's Guide) shall be available upon request and contain the information necessary to determine the nature and extent of the analysis, verify the input data, interpret the results, and determine whether the computations comply with these requirements.
- 11.3 A computer diskette containing a copy of the input file shall be furnished to Saudi Aramco for all computer models to aid in the review.
- 11.4 Computer programs such as STAAD III, STRUCAD, SAP2000, ETABS, PCA MAT, ENERCALC, ADOSS and PCA-COL are acceptable programs. Other commercial and proprietary software may be acceptable provided that the suitability and reliability of the results have been verified and that this verification is furnished upon request.
- 11.5 A summary of analysis results should be provided which are extracted from the computer output. This summary should clearly state the result achieved (e.g., maximum interaction ratios found, deflection ratios, etc.).

12 Civil/Structural Design Package Check List

Appendix A of this Standard contains a Civil/Structural Design Package Check List. This check list is provided to insure design package submitted for review are complete and in compliance with Saudi Aramco mandatory requirements. The check list summarizes key requirements in Saudi Aramco Engineering Standards, Material Specifications and Engineering Practices.

Revision Summary

31 August, 2002	Major revision. Added paragraphs 10.6, 10.9, 10.10 & 10.11, revised paragraphs 10.4 & 10.8, added Section 12 and Appendix A.
31 May, 2004	Remove reference to deleted standard SAES-M-008.

Appendix A – Civil/Structural Design Package Check List

General

Item	Yes	No	Item Description
1			Review Schedule: Does the design package allow adequate time for review as required by Para. 3.3.1 of SAEP-303? Project Proposal – 10 work days Detailed Design – 15 work days
2			Design Package % Completion: Is the design package percentage completion in accordance with Attachment 1 of SAEP-303? Geotechnical @ 30% Completion Civil @ 60% Completion Structural @ 90% Completion
3			Review Documentation: Is the number of submitted hard copies (unless electronic review is agreed upon) in accordance with Para. 3.4.1 of SAEP-303? Project Proposal – one hard copy of all documents per reviewing Division Detailed Design – one complete design package per reviewing Division
4			Scope of Work: Is Scope of Work included in the package as required in Attachment 1 of SAEP-303?
5			Review Documents: Are all the required documents included in the design package as required in Attachment 1 of SAEP-303? Civil Documents Geotechnical Documents Structural Documents* *Structural steel shop drawings and material take-off are not required for review and should not be submitted.
6			Drawings Index: Are drawings index in accordance with S. Aramco Standard Drawing AE-036411? Index A – Plot Plans Index M – Structural Steel Index Q – Concrete Index R – Architectural Index S – Civil Works
7			Structural Calculations: Are calculations performed in accordance with S. Aramco Engineering Standard SAES-A-204 "Preparation of Structural Calculations"?
8			Complete Design Package: Is the design package complete? Plot Plan drawings (Index A) Complete structural steel drawings (Index M) Complete concrete drawings including foundations (Index Q) Complete civil/drainage drawings (Index S) Complete Architectural drawings for reference & use (Index R) Complete structural steel calculations Complete concrete calculations including foundation design Block wall design if applicable

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Item	Yes	No	Item Description
9			Units: Are the calculations done using SI metric or Imperial units as required by Para. 5 of SAES-A-204?
10			Symbols: Does structural steel design have the same annotations or nomenclature? as in the AISC Steel Manual and the Concrete per ACI Code as required by Para. 6 of SAES-A-204?
11			Equations: Are all equations used in the design calculations clear and in accordance with Para. 7 of SAES-A-204?
12			Assumptions: Are assumptions used in the calculations listed in an orderly manner and based on sound basis as required by Para. 8 of SAES-A-204?
13			Parameters: Are the parameters used in the calculations justified as required by Para. 9 of SAES-A-204? This applies in particular to the following: <ul style="list-style-type: none"> <input type="checkbox"/> Temperature differentials <input type="checkbox"/> Allowable soil bearing pressure <input type="checkbox"/> Wind load calculations
14			General Presentation: Does the calculation presentations include the following as per Para. 10 of SAES-A-204? <ul style="list-style-type: none"> <input type="checkbox"/> Name of the Originator <input type="checkbox"/> Name of the Checker <input type="checkbox"/> Title which describes the contents of the calculations <input type="checkbox"/> Date of the calculations <input type="checkbox"/> Table of contents <input type="checkbox"/> Listing of codes and references <input type="checkbox"/> General description of the structural design methodology <input type="checkbox"/> Design criteria <input type="checkbox"/> Load derivation for all loads <input type="checkbox"/> Calculations accompanied by sketches <input type="checkbox"/> Calculations for special connections including beam/column moment connections (for structural steel)
15			Computer Calculations: Are computer calculations performed in accordance with following as per Para. 11 of SAES-A-204? <ul style="list-style-type: none"> <input type="checkbox"/> Computer input data initialed to ensure that it is checked <input type="checkbox"/> Computer models accompanied by sketches that show joint and member numbers, supports conditions and loadings <input type="checkbox"/> Computer output accompanied by the corresponding input <input type="checkbox"/> Computer diskette containing a copy of the input file <input type="checkbox"/> Summary of analysis results are provided or extracted from the computer output
16			STAAD III Computer Input – Design Parameters: <ul style="list-style-type: none"> <input type="checkbox"/> Are column members Kz and Ky (effective column length ratio) inputted in the design parameters? <input type="checkbox"/> Are columns Lz and Ly (unbraced length in local z and y axis) inputted in order to calculate columns slenderness ratio? <input type="checkbox"/> Are beams UNL (unbraced length) inputted in order to calculate the allowable compressive strength of the beams?
17			Competent Checker: Are calculation checked by competent checker?)

Buildings

Item	Yes	No	Item Description
18			Risk Assessment: Is risk assessment required for this building, and if so, is it included in the submittal as required by SAES-B-014?
19			Building Design: Does the scope of work define building type? <ul style="list-style-type: none"> <input type="checkbox"/> Regular building per SAES-M-100 <input type="checkbox"/> Blast Resistant building per SAES-M-009 <ul style="list-style-type: none"> o Is Blast Design Requirements (BDR) Data Sheet Included? <input type="checkbox"/> Pre-Engineered Building per 12-SAMSS-014 <ul style="list-style-type: none"> o Is Building Data Sheet Included? <input type="checkbox"/> Miscellaneous structure per SAES-M-001
20			Building Material: Is building material established? <ul style="list-style-type: none"> <input type="checkbox"/> Structural Steel Building <input type="checkbox"/> Concrete Building <input type="checkbox"/> Load Bearing block wall with concrete roof slab <input type="checkbox"/> Combination of Concrete and Block Wall system <input type="checkbox"/> Precast & Prestressed Concrete <input type="checkbox"/> Other (specify)
21			Structural Stability: Is building lateral stability established through- <ul style="list-style-type: none"> <input type="checkbox"/> Rigid moment connection frames (structural steel) <input type="checkbox"/> Braced Frames (structural steel) <input type="checkbox"/> Combination rigid and braced frames <input type="checkbox"/> Other systems (to be specified)
22			Longitudinal Stability: Is longitudinal stability of the building considered in the design calculation through – <ul style="list-style-type: none"> <input type="checkbox"/> Rigid moment connection frames (structural steel) <input type="checkbox"/> Braced Frames (structural steel) <input type="checkbox"/> Combination rigid and braced frames <input type="checkbox"/> Other systems (to be specified)
23			Building Roof/Floor Slab: Type of slab used? <ul style="list-style-type: none"> <input type="checkbox"/> One-way concrete slab <input type="checkbox"/> Two-way concrete slab <input type="checkbox"/> Composite decking concrete slab including shear connectors if composite structural steel beams used <input type="checkbox"/> Non-composite decking concrete slab <input type="checkbox"/> Slab supported by steel beams <input type="checkbox"/> Slab supported by truss or joist system <input type="checkbox"/> Other (specify)
24			Slab Thickness: Is deflection check performed to ensure that minimum slab thickness is in accordance with ACI Code requirements?
25			Foundation Type: Type of building foundation? <ul style="list-style-type: none"> <input type="checkbox"/> Spread footings <input type="checkbox"/> Combined footings <input type="checkbox"/> Strip footings <input type="checkbox"/> Mat footing <input type="checkbox"/> Other (specify)
26			Building Details: Are adequate plans, elevations and sections details provided on the drawings to illustrate the structural details of the building?

Structural Steel

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Item	Yes	No	Item Description
27			Steel Material & Grade: Is steel material and grade in accordance with Para. 4 of 12-SAMSS-007?
28			Connections Material & Grade: Are structural steel beams/columns/bracings connections material and grade in accordance with para. 4 of 12-SAMSS-007?
29			Anchor Bolts Material, Grade & Detailing: <input type="checkbox"/> Is anchor bolts material and grade in accordance with Para. 4 of 12-SAMSS-007? <input type="checkbox"/> Is anchor bolt detailing in accordance with the latest S. Aramco Standard Drawing?
30			Special Connections Details: Are special connection details including moment connection and bracing connections (vertical and horizontal) designed and detailed in the submitted design package?
31			Base Plate & Anchor Bolts: Are base plates and anchor bolts designed and detailed in the submitted design package?
32			Metal Decking: Is roof and floor slab Metal decking designed for the superimposed loads acting on it and technical properties included in the submitted drawings?
33			Grating: Is grating designed for the imposed live load and any traffic load acting on it? Does drawings specify grating fastening details
34			Roof or Floor Truss: <input type="checkbox"/> Are truss members connection details (welded or bolted) shown on the drawings? <input type="checkbox"/> Is truss members connection designed for the actual forces acting on them? <input type="checkbox"/> Is truss bottom chord properly braced?
35			Structural Steel Splices: <input type="checkbox"/> Are Column and beam splices (if required) locations shown on the drawings? <input type="checkbox"/> Are splices details shown on design drawings? <input type="checkbox"/> Are splices designed for the actual forces acting on them?
36			Jib Cranes: Are jib cranes designed for the applied loads for the full range of lifting positions including deflection checks (including those of the column) and eccentric loads causing major and minor axis bending and torsion on the column?

Foundations

Item	Yes	No	Item Description
37			Soil Bearing Pressure: <input type="checkbox"/> Is the footing actual soil bearing pressure less than the allowable soil bearing pressure as per soil investigation report recommendations (Ref. Para. 4.1.2 - SAES-Q-005)?
38			Footing Depth Below Grade: <input type="checkbox"/> Is footing depth below existing grade in accordance with soil report recommendation? <input type="checkbox"/> Is footing depth at least 600 mm below existing grade as required by Para. 4.1.3 - SAES-Q-005)?
39			Footing Obstruction By Underground Utilities: <input type="checkbox"/> Is footing location checked and verified against existing underground utilities in order to avoid possible interference during construction stage?
40			Projection of Pedestal: Is concrete pedestal extended a minimum of 150 mm above finished grade for columns supporting process equipments and piperacks? (Ref. Para. 4.3.2.a – SAES-Q-005)?
41			Concrete Strength: Is the design concrete compressive strength 4000 psi minimum? (Ref. Para. 4.3.2.b – SAES-Q-005)
42			Stability Ratio: Is the minimum safety factor against overturning in accordance with Para. 4.2.1 of SAES-Q-005?
43			Sliding Ratio: Is the minimum safety factor against sliding in accordance with Para. 4.2.3 of SAES-Q-005?
44			Footing Sizing: Are all the various critical service loads considered when sizing the footing?
45			Checking Footing Thickness: Are all the various critical factored loads considered when checking footing beam shear and punching shear?
46			Foundation Beam Shear: Is footing beam shear checked to be within the ACI Code limit?
47			Foundation Punching Shear: Is footing two-way shear checked to be within the ACI Code limit?
48			Footing Reinforcement: Is footing reinforcement checked against the minimum required by ACI Code?
49			Pedestal Reinforcement & Dowel Development/Splice Length: <input type="checkbox"/> Does pedestal design take into account vertical load and moment due to horizontal load and acting moment on top of pedestal? <input type="checkbox"/> Is minimum pedestal reinforcement checked against ACI Code requirements? <input type="checkbox"/> Is pedestal dowel development into footing checked against ACI Code requirements? <input type="checkbox"/> Is pedestal vertical bar splice checked against ACI Code requirements? <input type="checkbox"/> Is pedestal checked for its ability to transfer shear force at the face of column as required by ACI Code?
50			Anchor Bolts: <input type="checkbox"/> Is anchor bolt design in accordance with Para. 4.7 of SAES-Q-005 and ACI 318-02 Appendix D? <input type="checkbox"/> Are anchor bolts for heavy equipment match vendor drawings requirements? <input type="checkbox"/> Has the anchor bolt diameter been increased by 3mm in coastal areas as required in SAES-Q-005, paragraph 4.8.7.