



# Gulf Engineering House, Structural Department

Profile 2012-2013

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## 1. GULF ENGINEERING HOUSE

### 1.1 Introduction

The Gulf Engineering House (GEH) is a Saudi firm, which conducts studies/ consultation in the areas of pavement, GIS, traffic, transportation, highway, airport engineering, structural and architectural engineering. GEH is managed by a group of highly educated professionals. GEH consulting engineering staff consists of highly experienced and specialized engineers who are expert in the field of Highway, Airport Pavements and Traffic Engineering. GEH's commitment to quality, support and product integration will continue to play an essential part in the Group's strategy. GEH is structured into following divisions:

- Airport Division
- Traffic and Transportation Division
- Road and Highway Engineering Division
- Geotechnical and Materials Testing Division
- Geographical Information System (GIS) and Survey Division
- Structures Division
- Equipment Division

GEH has maintained a continuous presence in the Middle East for over several years and the Company is justifiably proud of its long-term association with the development of the region's industrial, commercial and civic infrastructure. GEH is having head office in Riyadh and other branch offices in different cities of Saudi Arabia. In addition, GEH has a branch office in Amman, Jordan. A view of GEH Head Office in Riyadh is shown below.



**Head Office of Gulf Engineering House in Riyadh, KSA**



GEH currently employ over **800** staff in the Middle East. The Riyadh Saudi Arabia is the centre of GEH Middle East operations with regional offices in Amman/Jordan, Jeddah, Mecca, Madinah, Qassim, Yanbu, Hafouf and Dammam. The regional offices employ over 884 expatriate and local staff comprising:

S.No	Staff	Numbers
1	Senior Engineers and Experts	35
2	Engineers	203
3	Technicians	440
4	Administration, Librarian and Printing Support Service Personnel	59
5	Technical Support	48
6	Workers	99

GEH staff have published over 60 papers on pavement management / traffic / transportation planning / materials and given numerous presentations on the topic throughout the world. The team's international exposure and involvement with pavement, highway, traffic & airport engineering will benefit any project greatly.

GEH is responsive to the changing needs of our clients caused by rapid growth, new technologies, new operating procedures and essential security requirements. In order to meet these client needs, our services cover the whole spectrum of development and include strategic planning, design, studies, infra-structure development and project management.

The GEH services are factored to meet the specific needs of the road and airport industry and provide clients with integrated consultancy services covering all areas of pavement evaluation, pavement management, highway design, bridge design, traffic, transportation planning, topographic survey, GIS application, geotechnical investigations, material testing, construction supervision, project management and value engineering.

Over a period of last Twelve years span GEH has spread its activities in diversified area of its expertise. The yearly financial turnover of GEH worth more than **300 million** Saudi Riyals. GEH areas of expertise include the following:

- Information Technology and GIS
- Traffic and Transportation engineering
- Instruments and Equipments
- Airport Engineering
- Architectural and Planning Engineering
- Structural Engineering
- Highway Engineering
- Geotechnical and Material Engineering
- Nondestructive Testing

## 1.2 Gulf Engineering House Clients

GEH is preapproved by most governmental agencies such as: (Ministry of Transport, Ministry of Municipal and Rural Affairs, Riyadh Municipality, Dammam Municipality, Jeddah Municipality, Mecca Municipality, Buraidah Municipality, Unaiza Municipality, and Ministry of Water and Electricity). Also GEH is preapproved by universities in Saudi Arabia such as: (King Fahd University of Petroleum and Minerals, King Saud University, Umm Al-Qura University, King Abdul Aziz University) and also private sector companies such as: (Aramco, Saudi Telecom company, Saudi Railway Company). Finally GEH is preapproved in a number of public and private bodies within the Gulf Cooperation Council (GCC).

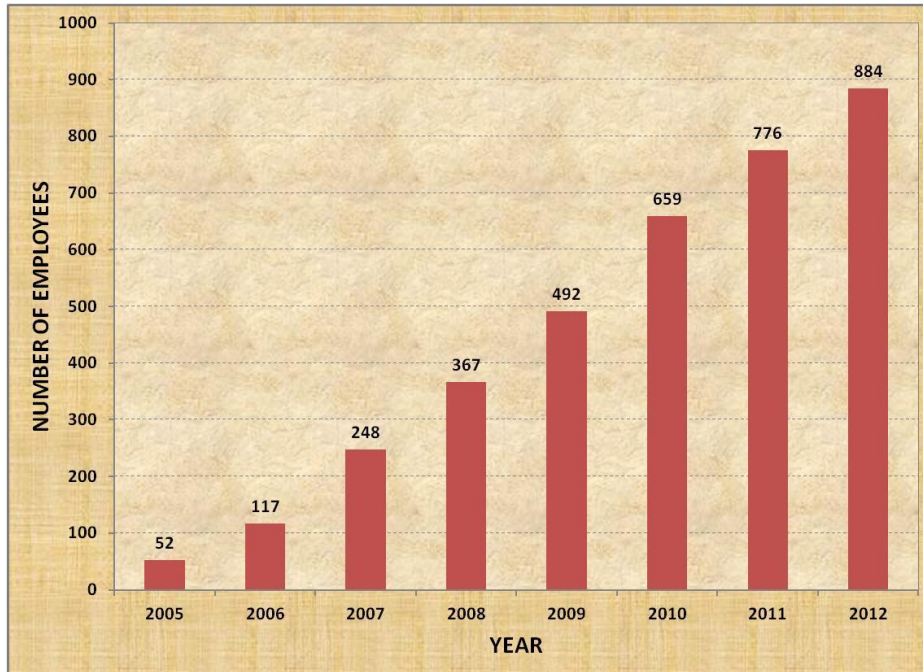


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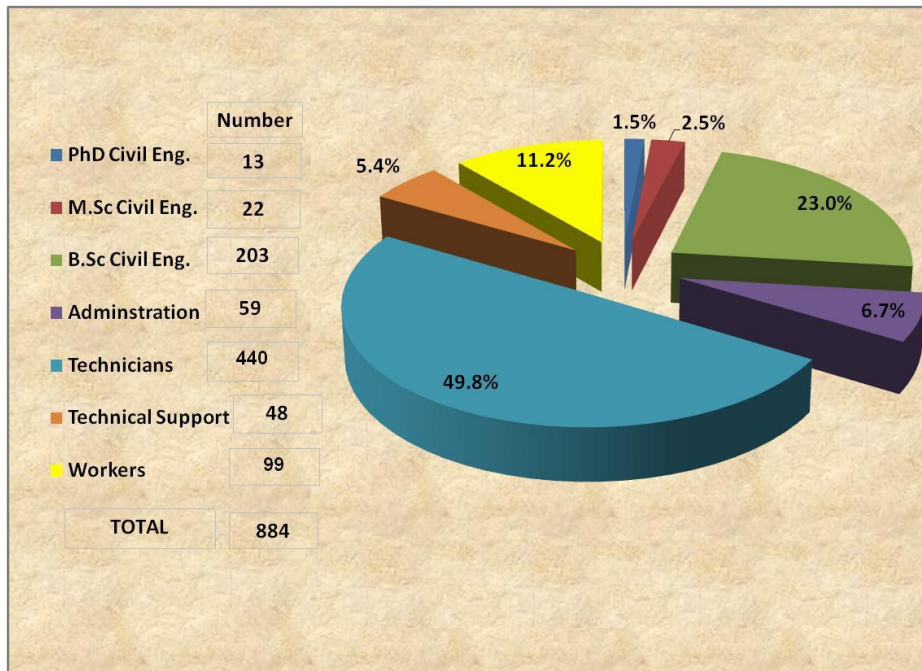




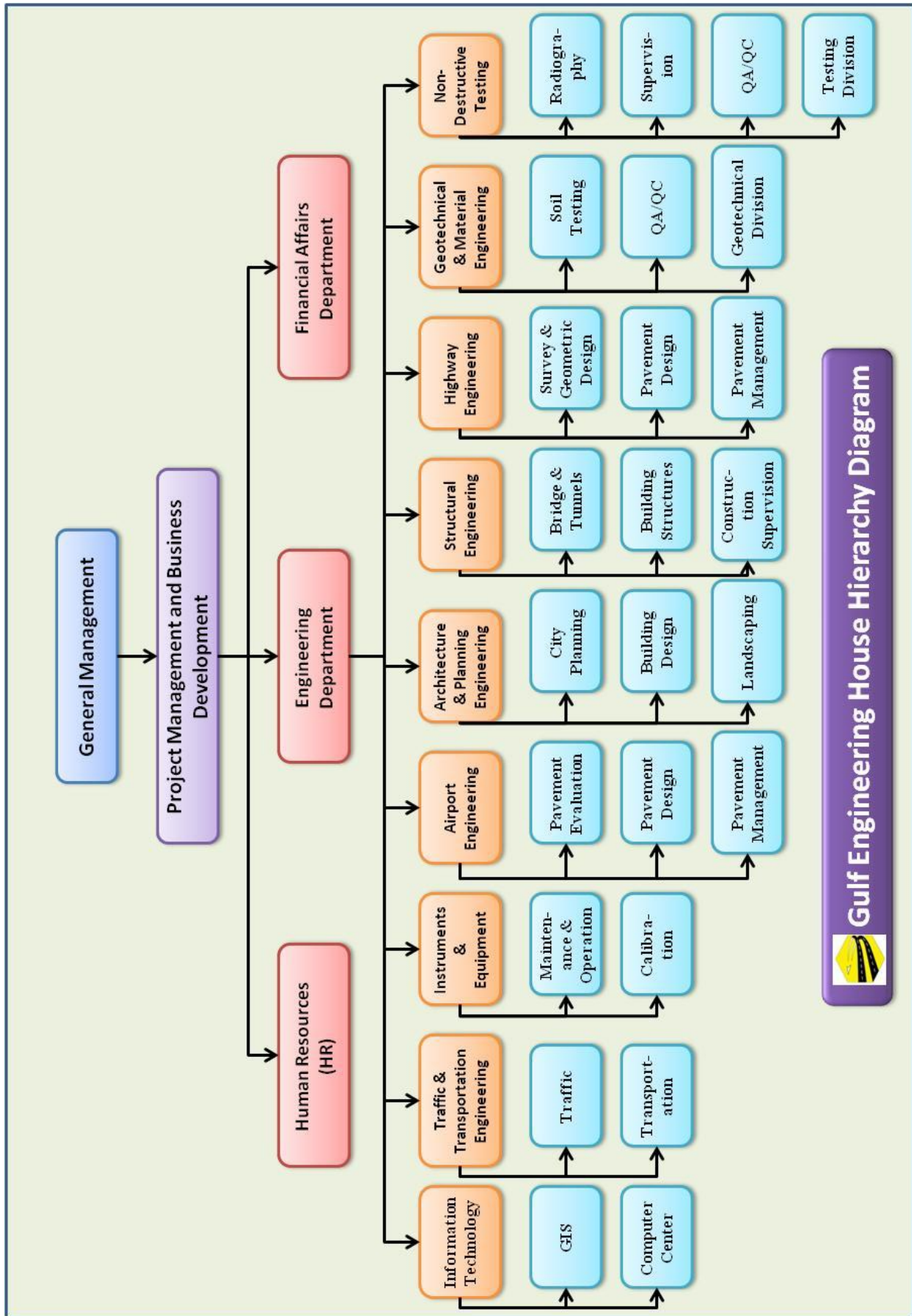
### 1.3 Growth, Classification and Number of Employees at GEH



Growth of employees between the year 2005 and the year 2012



Classification of employees for the year 2012



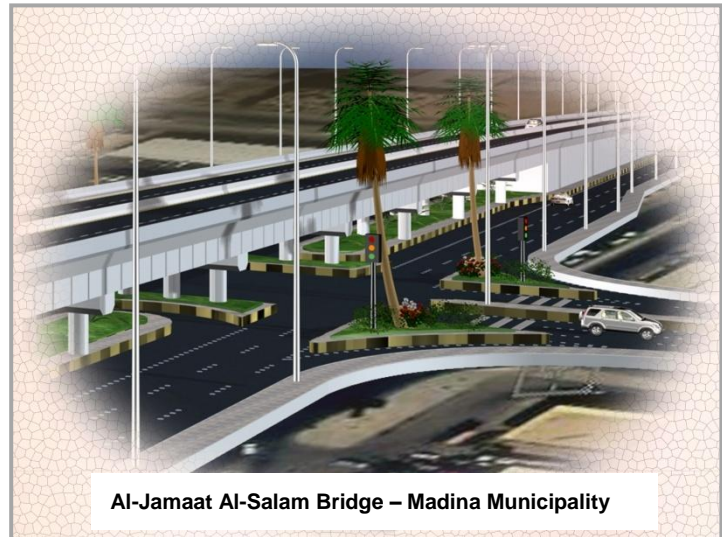
Gulf Engineering House Hierarchy Diagram



## 2. Experience and Qualification in the Field of Structural Design and Evaluation

### 2.1 Introduction

The Structural Design Unit (SDU) is one of the main departments in Gulf Engineering House (GEH), which provides engineering consultancy services in the form of structural design of projects that are awarded to the company from both the public and private sectors, which includes design of highway bridges, tunnels, and culverts. In addition, auditing and supervision of all projects of construction of bridges and tunnels that are awarded to the company as site supervision. Also the Structural Design Unit leads the design of commercial and residential buildings,



as well as, inspection and safety assessment of existing facilities including proposing programs for rehabilitation and proper maintenance of these facilities. The Unit implements its tasks through highly qualified technical staff with long experience; wide scientific knowledge and professional distinctive competence in the company's headquarter office in Riyadh/Saudi Arabia and its regional office in Amman/Jordan. SDU has achieved excellence and leadership in the performance of advisory services through number and level of projects carried out and fulfilled within the specified period of the contract.

### Consultancy Services Provided by Structural Design Unit:

- Complete design services, which includes:
  - Highway Bridges, Tunnels and Culverts
  - Commercial and Residential Buildings
- Construction Site Supervision
- Structural Assessment and Rehabilitation of Buildings and Bridges
- Construction management
- Feasibility studies
- Site surveys and investigations
- Technical training



## 2.2 Design of Bridges and Tunnels

Design of bridges and tunnels go through various stages starting with proposing the structural concept in compliance with the traffic solution and the geometric concept, and ends with the final structural analysis and design according to standards satisfying safety and economical cost requirements. Final design review is carried out along with preparation of final design drawings and documents. Such tasks may be listed in the following main items:

1. Approved design codes and standards to be used.
2. Description of bridges and tunnels design works
3. Software used in the analysis and design of bridges and tunnels.



### 2.2.1 Design Codes and Standards

1. The American Association of State Highway and Transportation Official (AASHTO), "AASHTO LRFD Bridge Design Specifications," 4th Edition, 2007.
2. The American Association of State Highway and Transportation Official (AASHTO)- "Standard Specifications for Highway Bridges– Division (I) 17th Edition 2002.
3. Ministry of Transport (M.O.T), "MOT Highway Design Manual) – Volume (3) – Structural Design Specifications 1993.
4. Precast/Prestressed Concrete Institute (PCI), "PCI Bridge Design Manual," Third Edition, 2011.
5. The American Association of State Highway and Transportation Official (AASHTO)- "LRFD Guide Specifications for Design of Pedestrian Bridges," 2nd Edition, 2009.
6. Federal Highway Administration, US Department of Transport, "Technical Manual for Design and Construction of Road Tunnels – Civil Elements," March 2009.

## 2.2.2 Description of Bridge and Tunnel Design

Bridges and tunnels design works may be summarized into the following main steps:

- **Preliminary design.**

According to the traffic study, a structural concept is proposed to meet the traffic proposal. At this stage the structural form is decided to be tunnel, underpass or overpass which will enable the geometric designer to suggest the geometric concept.

- **Prepare the preliminary structural proposals and concepts.**

According to the geometric concept, various structural parameters are suggested including total length and width of structure, number and length of spans and net clearance along with different conceptual structural options for dissection and final selection with client.

- **Specifying the suitable location of geotechnical boreholes.**

Once the conceptual structural system is selected and approved by client, the needed number, location and depth of bore holes will be recommended to the geotechnical department for complete field exploration, laboratory testing and reporting in accordance with professional and technical standards and practices.



- **Final structural solution and components.**

Preparing longitudinal and cross sections of all structural elements and specifying all design assumptions and materials properties which may include the followings:

- Construction Material to be used: Reinforced Concrete, Prestressed Concrete, Steel, and Composite...etc.



- Shape of superstructure cross-section: Box-Girder, T-Girder, I-Girder, and Slab...etc.
- Type of Bearings: Pot Bearing, Elastomeric Bearing, Steel Bearing...etc.
- Abutments: Closed Abutment, Counter Fort, Open Abutment...etc.
- Piers: Multi – Columns, Single Column, Wall Pier, Hummer Head...etc.
- Foundations: Spread Footing, Piles Footing.
- Retaining Walls: High Cantilever, Counter Fort, Mass Wall, Reinforced Earth Wall.
- Other Elements: Approach Slab, Barriers, Drainage Systems...etc.
- **Detailed structural analysis and designs.**
  - Preparing the final detailed analysis and design calculations of all structural elements including superstructure, substructure, retaining walls and other elements.
  - Proper design criteria including cement type, concrete and steel reinforcement properties, loads and forces, and loads types and combinations are implemented based on the Load Factor Design or Load Factor Resistant Design and procedures implemented in the Saudi Ministry of Transport Specifications for designing highway bridges and underpasses.
  - Dimensions, reinforcement, bearings and all other design details are obtained taking into considerations structural safety as well as economical cost requirements.
  - Designs are subjected to review by independent team.
- Preparation of structural design drawings.

Structural drawings are prepared using AutoCAD Program. Structural and construction details of all parts of structure including design assumptions, dimensions and reinforcements are included in the drawings.

- Preparation of contract and specification documents.
 

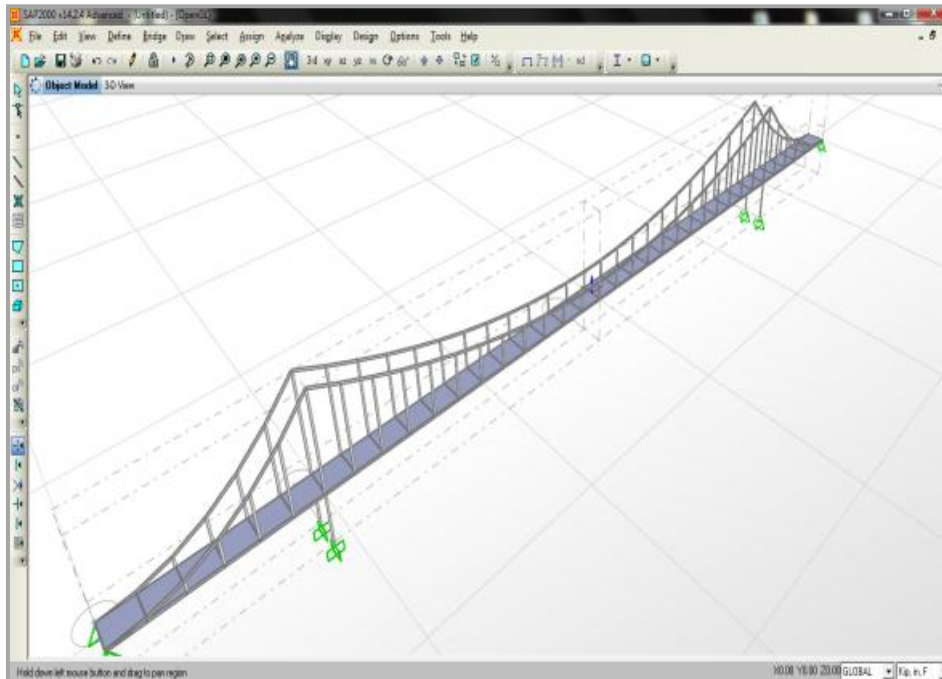
The technical specifications as well as contract forms and special and general contract conditions are prepared. These documents will ensure the accurate and proper way of execution of works in terms of materials properties, method of construction, quality control, methods of measurements and bases of payments.
- Preparation of cost estimate and bill of quantities
 

Bill of quantities (BoQ) for the structural works is prepared priced and unpriced.

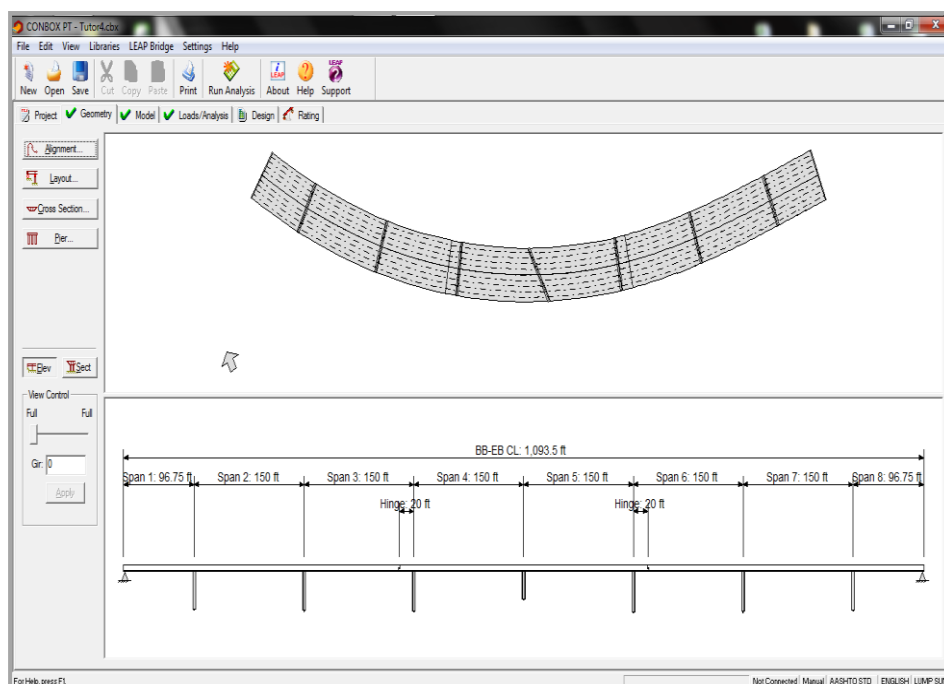
### **2.2.3 Software and Programs for Structural Analysis and Design**

- SAP2000 Advanced 14.2.4, Structural analysis program used for structural modeling.
- Staad Pro, Structural analysis program used for structural modeling.
- ConSPAN, version 7.0.0, this program is used for structural analysis and design of precast/prestressed superstructures of the form: box-girder, T- & I- & U- shaped girders.

- ConBox, version 7.0.1, used for structural analysis and design of RC and prestressed bridge superstructure of the following forms: Box-girder, solid slab and voided slab.

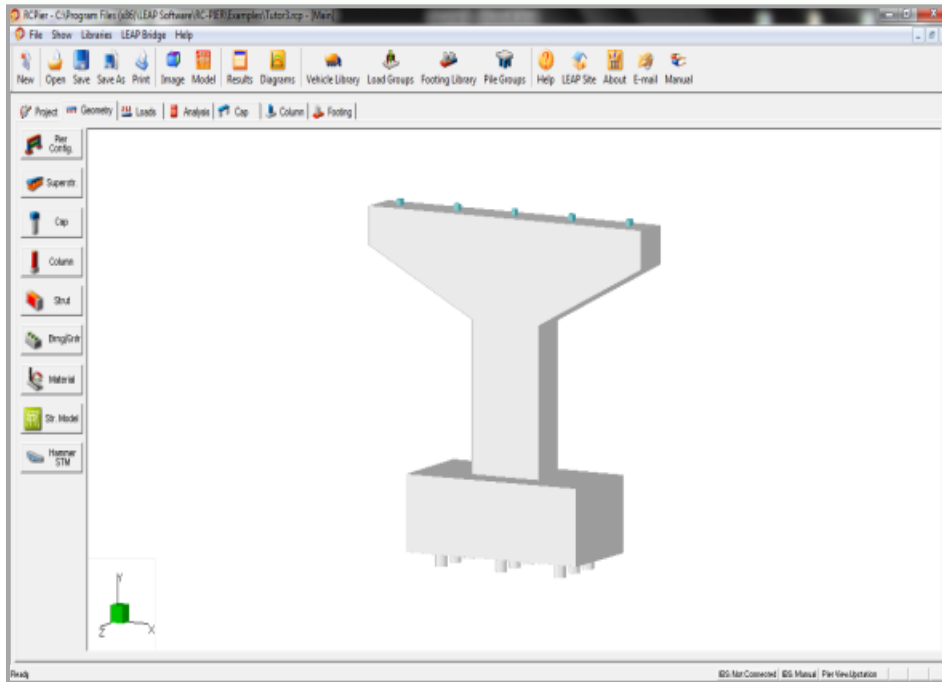


SAP2000 Software Snapshot



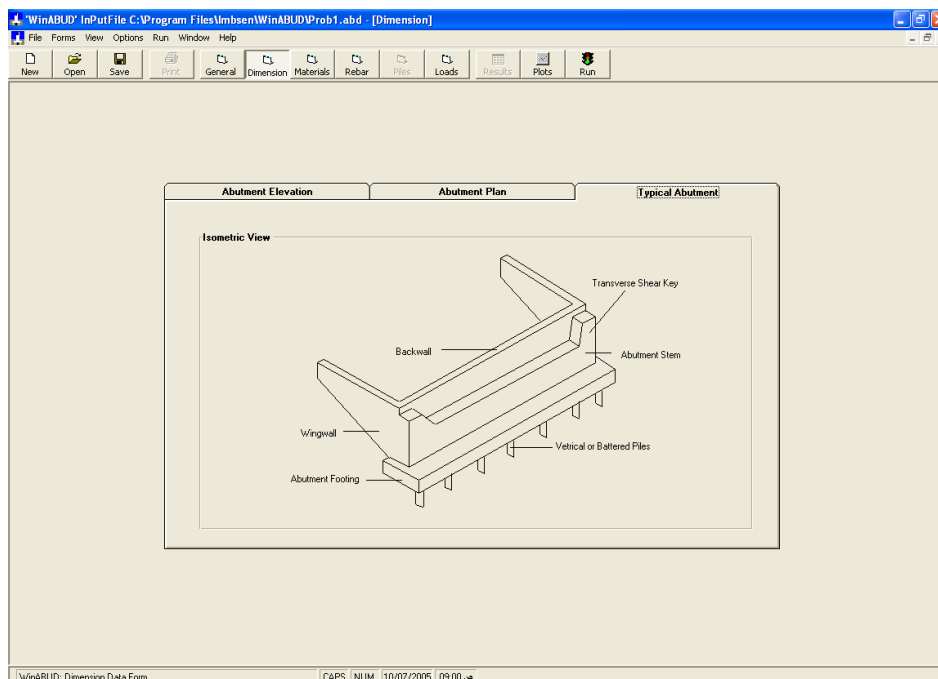
ConBox Software Snapshot

- RC-Pier, version 7.0.0, this program is used to design bridges bents/piers in various forms such as: Multi-column, Hammerhead, and Integral.
- WinABUD, this software is used for analysis and design of closed abutments.

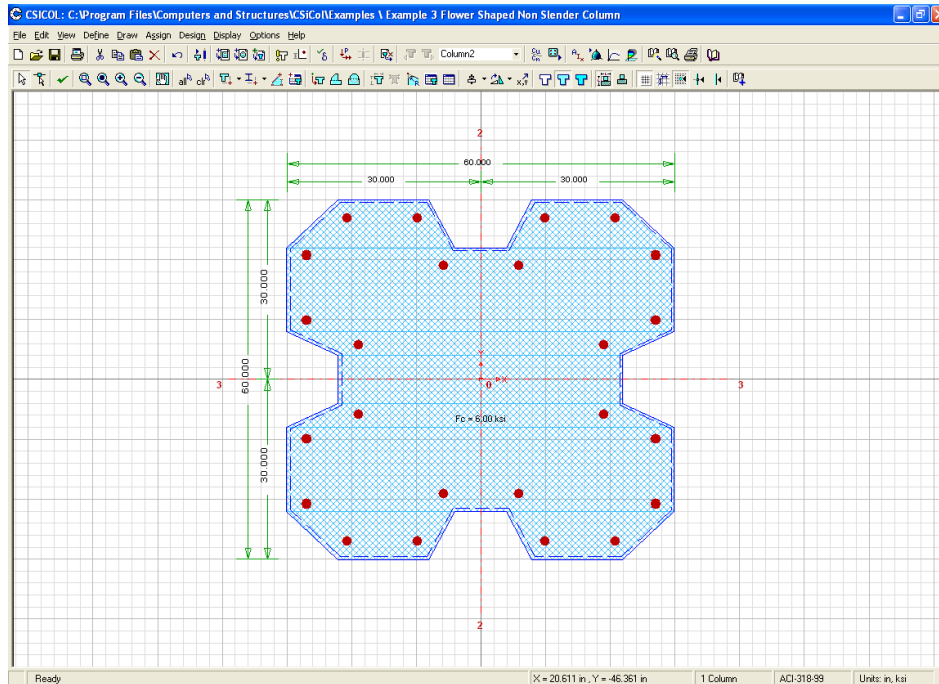


**RC-Pier Software Snapshot**

- QuickRC, this software is used for the analysis and design of reinforced concrete retaining walls.
- CSI-Column and PCA-Column, these software programs are used for the analysis and design of columns.
- In-house SPREADSHEET, which were developed by the SDU engineers to design various problems such as: bridge decks, open abutments, Prestressed Bulb Tee girders ... etc.



**WinABUD Software Snapshot**



CSI-Column Software Snapshot

### 3. Completed Projects

#### 3.1 Design Projects

##### 1. Design of the 4<sup>th</sup> Ring Road (RR) Interchanges in Mecca

- 4<sup>th</sup> RR and Jeddah Express Road
- 4<sup>th</sup> RR and Old Jeddah Road
- 4<sup>th</sup> RR and Al-Layeth Road
- 4<sup>th</sup> RR and Akashieh Road
- 4<sup>th</sup> RR and Jabal Thour Road
- 4<sup>th</sup> RR and Al-Madina Road
- 4<sup>th</sup> RR and Al-Sail Road

##### 2. Design of Al-Jamaat Road and Al-Salam Road Interchange Bridges for Al-Madina Al-Monawara Municipality.

##### 3. Design of Prince Abdulmajeed Road and the Airport Road Interchange Bridges for Al-Madina Al-Monawara Municipality.

##### 4. Design of King Fahd Road and Al-Arab Road Interchange Bridge for Skaka Municipality.

##### 5. Design of King Fahd Road and King Abdul-Aziz Road Interchange Bridge for Skaka Municipality.





Al-Jamaat Al-Salam Bridge –  
Madina Municipality

6. Design of King Fahd Road with King Khalid Road Interchange Bridge for Skaka Municipality.

7. Design of Prince Abdulla Road and Souq Al-Ghanam Road Interchange Bridge for Skaka Municipality.

8. Design of King Abdulla Road and King Fahd Road Interchange Bridge for Ihsa Municipality.

9. Design of King Saud Road and Al-Diwan Road Interchange Bridge for Ihsa Municipality.

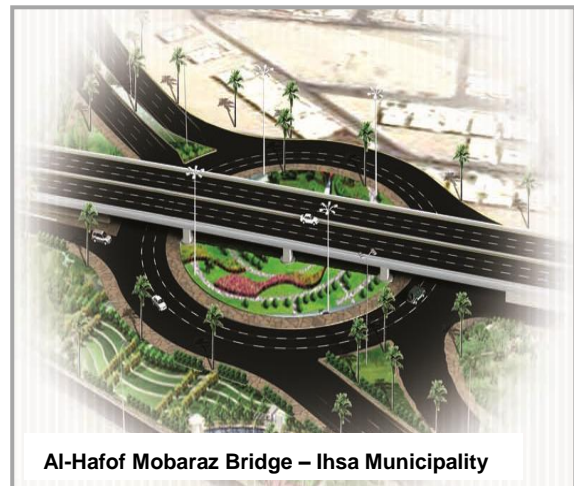
10. Design of Entrance of King Abdul-Aziz Marine Base and King Abdul-Aziz Road Intersection Bridge for Jubeil Municipality.

11. Design of Prince Naeif Road and Prince Faisal Road Intersection for Ihsa Municipality.

12. Design of Abdullah Orafe Road, Old Jeddah Road and Hajoun Street Interchange for Makah Municipality (4 bridges and tunnel).

13. Design of Taef-Hada Road and Ibrahim Jafali Street Intersection for Makah Municipality.

14. Design of Masjid Haram Road and Sidqy Street interchange for Makah Municipality.



Al-Hafof Mobaraz Bridge – Ihsa Municipality



White Horse Bridge – Jeddah Municipality

15. Design of Masjid Haram Road and Jameah Street interchange for Makah Municipality.

16. Design of King Fahd road and Rawdah Steet (Darajah) Interchange for Jeddah Municipality (Precast/Prestressed Bridge).

17. Design of King Fahd Road and Sary Street (Falak) Interchange for Jeddah Municipality (Tunnel).

18. Design of King Fahd Road with Herra Steet (White Horse) Interchange for

Jeddah Municipality (Precast/Prestressed Bridge).

19. Design of Wadi Rmah and Shuweiah Road Interchange for Riyadh Municipality.

20. Design of UR4 Bridge at km 139+637 at North-South Railway for Saudi Railway Company (SAR).



Al-Diwan Bridge – Ihsa Municipality

21. Design of UR2 Bridge at km 12+332 at North-South Railway for Saudi Railway Company (SAR).

22. Design of UR4 Bridge at km 88+626 at North-South Railway for Saudi Railway Company (SAR).

23. Design of King Saud Road and King Abdullah Road Interchange for Khamis Mushait Municipality.

24. Design of King Khalid Road, King Faisal road and Prince Sultan Road

Interchange for Khamis Mushait Municipality.

25. Design of King Fahd Road and Bahes Street Interchange for Khamis Mushait Municipality.

26. Design of (11 Bridges) in Hima Al Mashaer Project for Makah Municipality.

27. Design of Shubra Street and Al-Jaish Street Interchange for Taef Municipality.

28. Design of Al-Jaish Street and Al-Salama Street Interchanges for Taef Municipality.

29. Design of North-South Axis for Taef Municipality.



Al-Jaish and Al-Salama Tunnel – Taef Municipality

### 3.2 Inspection, Evaluation, and Rehabilitation Projects

GEH provides consultancies for inspection and safety assessment of existing facilities including proposing programs for rehabilitation and proper maintenance of these facilities. This is achieved through the development and implementation of proper methodologies based upon international standards and using state-of-the-art equipment. The assessment includes detailed information about types of damage and its causes, and development of a detailed plan of options for necessary maintenance procedures for these facilities. Herein some of the evaluation and rehabilitation completed projects:

#### 1. Detailed visual survey of all highway bridges in the Kingdom of Saudi Arabia under the authority of Ministry of Transport (MoT)

It includes a comprehensive assessment of bridges in the Kingdom of Saudi Arabia under the authority of Ministry of Transport to prioritize maintenance and propose the necessary procedures for the periodic maintenance of these bridges. A comprehensive evaluation and



rating of all bridges in the Kingdom of Saudi Arabia was achieved, leading to suggested rehabilitation procedures and periodical maintenance programs of all bridges.



## 2. Evaluation of Wadi Waj Culvert project (Taef Municipality).

The culvert follows the path of Wadi Waj (Waj valley) in Taef of a total length of 7.7 Km. The evaluation process started with visual inspection of the facility, which revealed some problems in the structure such as:

- Structural cracks in the wall and top slab of the culvert
- There is abrasion in the culvert floor due to water flow
- Bad construction of the upper inlets
- Spalling in the top slab concrete cover due to reinforcement corrosion.
- Leakage in the expansion joints which exists every 12m along the culvert.



Based upon visual inspection and preliminary analysis, several standard tests were decided to quantify the existing damage. The table below shows some of the nondestructive tests that GEH is capable of executing.

Test Name	Purpose of Test	Equipment	Standard
Pullout Strength of Hardened Concrete	covers determination of the pullout strength of hardened concrete by measuring the force required to pull an embedded metal insert and the attached concrete fragment from a concrete test specimen or structure	CAPO	ASTM C900-99 BS 1881 Part 207
Determining Strength Development of Adhesive Bonds	This practice covers the determination of the strength development of adhesive bonds when tested on a standard specimen under specified conditions of preparation and testing	BOND	ASTM D 1144 BS 1881: Part 207
Chemical Analysis of Hydraulic Cement	These test methods cover the chemical analyses of hydraulic cements. Specific chemical test methods are grouped as reference test methods and alternative test methods.	RCT	ASTM C 114 AASHTO T 260
HUM-meter Indicating Moisture in Concrete	This test method is used to indicate the presence of capillary moisture in concrete.	HUM-METER	ASTM D 4263
Rebound Number of Hardened Concrete	This test method is applicable to assess the in-place uniformity of concrete, to delineate regions in a structure of poorer quality or deteriorated concrete, and to estimate in-place strength.	Rebound hammer	ASTM C 805
Crack width	Determine crack width and length	Template Gauge	---
Pulse velocity through concrete	Uniformity and relative quality of concrete	Pundits Ultrasonic Tester	ASTM C 597 BS 1881-203
Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration	Laboratory evaluation of the electrical conductance of concrete samples to provide a rapid indication of their resistance to chloride ion penetration	Rainbow Indicator	ASTM C 1202-97
Sampling and Analysis of Existing Built-Up Roof Systems	This practice is a guide for removing test specimens from existing built-up roofing systems in the field and for determining the approximate quantities of the components of that specimen	Coring-Machine	ASTM D 2829
Rebar Locator	Finding the location, depth, and size of steel reinforcement bar, post tension cables, copper and conduit in concrete brick, masonry or other non-metallic construction materials.	R-Meter M-K III	ACI 318 , BS 51881 Part 204

*Rebar Locator**Reinforcement Corrosion*

### 3.3 Construction Supervision Projects

GEH oversees the implementation of many of bridge projects in the Kingdom of Saudi Arabia including municipalities of: (Mecca, Qassim, Hail, Jizan, Ihsa) under the authority of Ministry of Transport or Ministry of Municipal and Rural Affairs. The following is a list of some of these projects:

1. Al-Sho'ba Interchange Bridge in Araa'r
2. Araa'r Airport Interchange Bridge
3. King Fahd Road and King Abdul-Aziz Road Interchange Bridge in Breiydah
4. King Fahd Road and King Abdulla Road Interchange Bridge in Breiydah
5. Uneiza - Airport Road and Riyadh – Madinah Munwarah Road Interchange Bridge in Qasim.
6. Uneiza - Airport Road and Wadi Ramad Interchange Bridge in Qasim.
7. Uneiza - Airport Road and Farms Road Interchange Bridge in Qasim.
8. Development of King Abdulla Road in Breiyda – Al Nahdah Bridge.
9. Development of King Abdulla Road in Breiyda – Al Tagheirah Bridge.
10. Badae' Al-Khobara Interchange Bridge in Qasim.
11. Rubeiya Breiyda Shamasieh Bridges.
12. Rubeiya Al-Asiyah Bridges.
13. Al-Arda-Al-Eidabi Bridges in Jizan.
14. Al-Arda-Abu Ereish Bridges in Jizan.
15. King Abdulla Road with King Fahd Road Interchange Bridge in Ihsa (Connecting Bridge between Hofouf and Mubaraz).
16. Intersection between 4<sup>th</sup> Ring Road and Al-Laith Road in Mecca.



17. Haeil Jubba Bridges in Haeil.
18. Al-Sunboleh Bridge in Haeil.
19. Diwan Road and King Saud Road Interchange Bridge in Ihsa.
20. King Abdul Aziz Road with King Fahd Road Interchange Bridge in Ihsa.
21. King Abdullah Road and the Northern Radial Road Interchange Bridge in Breidah.
22. 4<sup>th</sup> Ring Road and Express Jeddah Road Interchange in Mecca.
23. The implementation of the expansion of the women's department in Prince Salman Social Center in Riyadh

## 4. Technical Staff and Expertise

The Structural Design Unit (SDU) team consists of a number of doctoral, master's and bachelor's degrees holders in Structural Engineering and experience ranging from two to twenty-five years. Herein are some key personnel:

### Dr. Mohammad M. Smadi

*A Professor of Structural Engineering, holding a Ph.D. degree from Cornell University – USA. Worked as staff member in various Jordanian Universities (Yarmouk University, Jordan University of Science and Technology, University of Jordan, Al-Isra University), as well as King Saud University in the Kingdom of Saudi Arabia. He had held positions like department head and faculty dean. Worked in many consulting national and international structural engineering projects, and offered various technical workshops on different aspects of structural and bridge engineering. Author of many technical papers in an international Indexed Journals and Conferences. Currently working as an expert of structural engineering at Gulf Engineering House.*



### Dr. Hazim M. Dwairi

*Associate Professor of Structural Engineering, holding a Ph.D. degree from North Carolina State University (NCSU) – USA. Worked as a lecturer and visiting professor at North Carolina State University, also worked as Associate Professor at Hashemite University – Jordan. He worked in the field of engineering consultancy in Jordan and Saudi Arabia as well as USA, and oversaw the design of many projects, bridges, buildings, water tanks and a variety of the engineering consultancies and training courses in Bridge Engineering and Engineering Seismology. He also participated in the preparation of studies of seismic analysis and design of a number of bridges in Jordan and the United States. He has many publications in refereed world class journals, also participated in many international conferences. He is currently a structural engineering expert at Gulf Engineering House in Riyadh, and SDU manager at Amman's regional office.*



**Dr. Adel I. Mohammed**

*Holds a PhD degree of Building Materials and Construction in 1999 from Donbass State Academy of Building and Architecture, Makeyevka, Ukraine. He worked as a laboratory supervisor at Donbass State Academy responsible for testing of structures. He also worked for over 10 years in various Ukraine Companies such as Erbek Construction Company designing various types of structures. He also worked for Alumir, a Turkish company, as a structural engineer. Currently he works as a structural expert at Gulf Engineering House.*

**Eng. Orwa K. Ebrahim**

*Holds a master's degree of Civil Engineering from the University of Sudan for Science and Technology - Sudan, he worked as a faculty member at the University of Sudan University of Science and Technology, he also worked in the field of engineering consultancy in the Sudan and Saudi Arabia. He participated in the preparation of studies and designs for many of the bridges. He is currently structural design unit Manager at Gulf Engineering House in Riyadh.*

**Eng. Issa M. Issa**

*Holds a Master's degree of Civil Engineering, specialty in Bridge Engineering in 2010 from University of Houston / Texas, USA. He worked as a Research Assistant and a Teaching Assistant at the Universities of Missouri / Rolla, and University of Houston / Texas. He was a member of the research team funded by the Department of Roads and Transport in the state of Missouri to study the defects of bridges in the state of Missouri and provide economical solutions. Worked for a year as a structural design engineer at consolidated consultants (CC) in Jordan. Currently he works as a bridge engineer at Gulf Engineering House.*

