KHALID S. DINNO, Ph.D., P. Eng.

Designated Consulting Engineer

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SPECIALIZED PROFESSIONAL COMPETENCE

- Failure investigations of industrial plants
- Failure Analysis of Structural and Mechanical Components
- Failure of Pressure Vessels and Boilers
- Heavy Civil and structural Engineering
- Product Liability
- Application of engineering codes, standards and workplace regulations

ACADEMIC BACKGROUND

- Bachelor of Technical Science, First Class Honours
  University of Manchester, UK 1962
- Master of Technical Science
  University of Manchester, UK 1963
- Doctor of Philosophy
  University of Manchester, UK 1965

1965 – 1994 Professor in engineering, University of Baghdad.
1972 – 1973 Visiting lecturer, University of Manchester, U.K.
1994 – 1995 Visiting Professor, University of Toronto
1995 – 1998 Adjunct Professor, University of Toronto
(lecturing on structural steel design to graduate students, and on failure analysis & forensic engineering in a professional development course)
Seminars on Failure Analysis & Forensic Engineering to professional Engineers, at the Professional Development Centre, University of Toronto.

AWARDS

- Awarded the Ludwig Mond Prize by the Council of the British Institution of Mechanical Engineers in 1976 for his work on “The Lower Bound Limit Pressure Analysis for the Oblique Intersection of a Flush Cylindrical Nozzle and the Toroid of a Cylindrical Vessel with a Torispherical End.”

COURT APPEARANCES
Qualified as an expert in structural engineering in Ontario courts on multiple occasions.

PROFESSIONAL BACKGROUND

Over 45 years of experience in the engineering profession covers a wide spectrum of consulting functions in analysis, design, site supervision and failure investigations:

- Design and site supervision of civil and structural engineering projects. These included: industrial plants, roads, bridges, and other heavy civil engineering structures, such as tanks, towers and silos, in steel and concrete; the process design of water and sanitary treatment plants.
- Extensive involvement in the investigation of failures and damage assessment of a wide variety of industrial plants, buildings and structures. These include:
  - failure of industrial equipment such as mills, digesters, blenders,
  - failure of cranes, hoists and elevating devices,
  - failure of materials handling equipment,
  - failure of building structures, including failure of bridges, towers, silos, tanks, parking structures and foundations,
  - vibration problems in industrial foundations,
  - corrosion and stress failures of metals, and
  - weld failures.
- Structural damage assessment of industrial plants and buildings caused by fire.
- Wide experience in boilers and pressure vessels.
- Product liability cases involving a wide variety of products, components and machine performances.
- He appeared as expert witness and arbitrator in many litigations.
- He is the author of more than 40 scientific and professional papers.

EXAMPLES OF PROFESSIONAL EXPERIENCE

1. Examples Forensic Engineering Investigations

Collapse of Mine Storage Shed Roof Structure under Construction and Assessment of Roof Panel Compliance with Code Required Diaphragm Capacity
Covered mineral storage facility (440 ft. x 160 ft.) with reinforced concrete walls supporting steel roof frame on which plywood roof sheeting was to be installed. The steel roof frames collapsed during a high wind event before the sheathing had been installed. The bracing in place during construction was assessed. Subsequently the design of the stressed skin composite roof design was investigated with contributions from multiple researchers in this type of system.

Partial Roof Collapse at Paper Mill
A portion of the roof (60 ft. x 420 ft.) collapsed due to the failure of multiple roof joists after a rain event. Investigation on site and calculation showed corrosion of the joist had led to overstressing of certain joists, leading to ponding, further overstress and eventual collapse.

Condition of Metal Silo Following Explosion
The top of the 60 ft. silo was blown off. Detailed examination of the silo allowed us to conclude the damage effects expected from a significant over pressure such as exterior tension cracks at the welds between the aluminum plates were not present. The silo was placed back into operation.

Tornado Damage to Above Grade Mine Structures
On August 21, 2011 a F3 tornado made landfall at the salt mine in Goderich ON. It tore large portions of roof from the salt storage domes and brick buildings at the facility. The operator of the rail guided box truss conveyor ship loader was killed. The response of the ship loader to the tornado was modelled in response to a Ministry of Labour Investigation. Detailed documentation of the damage to the structures was carried out as part of the insurance process.

Pulp Digester: Investigation into the Collapse of a Centre Pipe
Design Audit and Stress Analysis of Retrofit Using Duplex Steel
The centre pipe in large pulp mill digester collapsed with the cause identified through structural and metallurgical investigation. Following the collapse the piping arrangement at top of the digester (a pressure vessel) was to be rearranged. Conventional and FEM structural analysis of the resulting stress changes was carried out.

The flowing list indicates the scope of his forensic engineering practice:

- Wind Damage and Collapse of Marina Structures
- Gas Explosion Damage to Several Houses
- Wind Damage to Concrete Silos
- Wind Damage to Steel Silos
- Fire Damage to Commercial Properties
- Highway Bridge Damage due to Vehicle Impact
- Railway Bridge Damage due to Vehicle Impact
- Flood Damage due to Land Drainage Failure
- Structural Damage to Overhead Transport System in Cement Plant
- Skid Failure at Loading Docks
- Fire Damage to Saw Mill Structure
- Safety Investigation Associated with Structural Demolition
- Gas Explosion Damage to Several Houses
- Large Diameter Water Main Failure
- Warehouse Roof Damage Assessment and Repair
- Major Investigation into Fire and Press Failure Causes of Oriented Strand Board Plant Including Mechanical, Metallurgical, Structural, and Control Systems

- Dump Truck Failure
- Investigation of Collapse of Steel Silos
- Fire Damage to Concrete Silos
- Failure of a freight securement system leading to train derailment
- Failure of structural walls leading to fatality
- Structural failure of excavator boom
- Collapse of a major underground parking structure
- Collapse of an air supported golf dome in Windsor, Ontario
- Collapse of an air supported golf dome in Niagara, US
- Serviceability failure in a large reinforced concrete water reservoir
- Collapse of a large industrial roof under snow loading
- Failure of a crane/chain lifting assembly in an industrial plant
- The fatigue failure of a large industrial mixer
- The fatigue failure of the frames of a 6,000 ton capacity press
- The failure of the bronze adjusting mechanisms of an industrial press
- The collapse of large gold iron ore silos in Chile
- The collapse of several steel and concrete silos
- Various pressure vessel and boiler failures
- Gear and bearing failures in a paper mill
- Fatigue failure in a mill in a mining facility
- Several industrial and construction crane collapse investigations
- Steel tank implosion failure in an industrial plant
- Material failure in a large industrial furnace
- The cracking of press rams of a hydro forming press
- Explosion failures in dust collecting systems
- Metallurgical failures in papermaking calenders
- Corrosion problems, their causes and their impact on strength and durability
- Instability failure of bridge scaffolding
- The collapse of a vehicular bridge
- The assessment of fire damage in grain storage structures
- The assessment of fire damage in processing plant
- Various failures in underground parking structures
- Foundation failures in ice rinks and floor heaves in industrial freezers
- Numerous structural and building failures in industrial, commercial, utility, municipal and residential construction

2. Bridges

Chenail Island Bridge, Hawksbery, Ontario. Part of the Perley Bridge Replacement Project.

Responsible for analysis and design of the steel superstructure and bearings. The bridge is a two span (each 40.6 m) continuous steel girder/concrete slab deck bridge which is curved in plan with skewed supports. The design was carried out to Canadian Standard for Highway Bridge Design CSA-S6.

Al-Ghizaila Bridge and approach road network.
The 200m long precast pre-stressed concrete deck highway bridge was constructed in the marshland in southern Iraq (1975-77). The difficult hydrological and geotechnical conditions presented interesting challenges in the construction of the substructure.

Preliminary studies, structural design and preparation of contract documents for construction of following bridges:
Five highway bridges over Falluja River

3 *Steel Towers*

Design, design audit and failure investigation of power transmission and communication towers. The work done fell in one of the following three groups:

a) Design of power transmission towers to serve different regions of the national grid of Iraq. In addition to the operational loading, different environmental loading conditions were in effect: snow and wind and earthquakes in the mountainous North and strong winds in the South. Soil conditions were vastly different in various locations.
b) Damage assessment and rehabilitation work of Gulf War damaged power transmission and communication towers.
c) Conversion of power transmission towers to antenna supporting towers, taking into account their different function, loading and serviceability requirements.

4. *Industrial Plants / Structural Work*

Kennedy Go Station, Toronto
A reinforced concrete underground station to be constructed in a critical location adjoining CN lines, foundation of Scarborough Rapid transit overhead system and TTC underground tunnels. The design caters for piercing and access to an existing TTC passageway tunnel.

Samawa Cement Plant
New cement production line, 1/2 million ton capacity including crushers, raw mills, slurry basins, slurry silos, kiln foundations, clinker transport system (1978). Major repair and maintenance work involving slurry basins, silos, cement grinding plant, chimneys etc. (1982).

Um Qasr Cement Plant
Cement grinding plant - 1/2 million ton capacity including receiving bunkers, cement mill buildings, 10,000 ton capacity cement silos and cement conveying systems for bulk shipping.

Kirkuk and Kerbala Cement Plants

- Checking and issuing of approval for the design prepared by Krupp Polysius (Germany) of two large cement plants each 2 million ton capacity, Each plant featured:

- 100,000 ton clinker storage hall, constructed of clad pyramid shaped steel structure 100 m diameter. Supported on peripheral columns.
- 80 m high, 16 m diameter. Pre-stressed concrete raw mill silos.
- ditto but 60 m high cement silos.
- 100,000 ton capacity raw mill storage hall constructed of clad hemispherical steel structure 100 m diameter supported on peripheral columns.
- Kiln foundations, raw mill plant, cement mill plant, crusher plant, packing plant and other facilities and utility installations.
- It may be of interest to note that the client requested the checking when about 50% of the construction was completed. The checking revealed serious design problems in the large storage halls which necessitated ordering wind tunnel tests to establish proper wind loading and to carry out major modifications to the already constructed structure to assure proper stability. Design problems were also encountered when checking the vibration characteristics of the raw mill and cement mill foundations. The predicted problems were actually experienced on the trial operations of the plant and consequently, careful measurements of vibrations were conducted and major modifications had to be undertaken to rectify the mill foundation system.

Falluja Cement Plant
Major repair and maintenance work in Falluja Cement Plant, including settlement problems of kiln foundations and slurry basins (1983).

5. Sanitary Schemes and structures

Very wide experience in the handling of water supply and sewerage schemes. This covered the full spectrum of detailed design, writing of specification, preparation of tender documents, site supervision and project management. In most cases the construction of the networks involved operating in very difficult soil conditions. The following are examples from over forty schemes for which he was responsible:

- Gayara Sewerage Scheme. This involved a 16 km network, 3 area pumping stations and a sewage treatment plant to serve a population of 50,000. Freezing soil conditions feature predominantly throughout the construction of the network.
- Mowasal Sewerage Scheme. This involved a 12 km network, 3 pumping stations and a treatment plant to serve a population of 30,000. Rock soil was encountered about 1 metre below ground surface. Use of explosive charges was resorted to in most of the network excavation.
- Kut Sewerage Scheme: The sewage network and treatment plant were constructed to serve a population of 35,000. The network had to be laid in loose sandy soil under the ground water surface which presented challenging dewatering and pipe laying conditions.
- Habania Sewage Network: Constructed to handle a population of 40,000, the network involved GRP pipes up to 600 mm in diameter which were laid at depths reaching 6 metres below ground water surface in a semi-fluid silty clay soil. Work was completed in 1984.
- Baquba Water Treatment Plant: a 40 million gallon capacity water treatment plant comprising intake, underground low lift pumping station, six-50 metre diameter clarifier

tanks, filters, 50,000 cubic metre capacity ground storage tank and high lift pumping station. Work was completed in 1986.

- Al Daura Water Treatment Plant: a 25 million gallon water treatment system comprising all the usual structures. Due to weak soil 35 metre concrete piles were used under all major structures. Work was completed in 1989.

6. *Evaluation, Repair and Rehabilitation of Gulf War Damaged Structures*

First Garmat Ali Bridge, Near Basrah, Iraq
A 407 m long highway bridge of nine 37 m spans of pre-stressed girder and reinforced concrete slab construction and two 37 m continuous steel spans which rotated over a central pier for navigational purposes. In addition to the complete or partial collapse of the concrete spans, the air strikes caused the steel spans to move bodily 3 m sideways and tilt transversely at a dangerous slope of 20% and caused the huge supporting cylindrical pier to tilt breaking away from 11 of the 12 large diameter supporting piles. Investigation of failure, formulation of solutions capable of execution within severely limited resources, analytic and design work and supervision of construction yielded most unique and valuable experience.

Second Garmat Ali Bridge - Near Basrah
A similar bridge which suffered greater damage in both the concrete and steel spans. The re-constructed bridge was reopened on September 9, 1993.

Zubair Highway Bridge, over Shatt Al-Arab River
The twin rotating steel spans (94 m long) of this bridge suffered extensive damages for 8 direct aerial strikes. Webs of 3 m deep steel girders were blown out or buckled, 100 mm thick flanges were torn, and the whole configuration was badly distorted. A successful system of temporary supports and repair was elaborated to restore the 800 tone steel construction to original strength and alignment.

Mohammed Al-Qassim Bridge, Over Shatt Al-Basrah
Somewhat similar to Zubair bridge, this bridge too received extensive damage. The repaired bridge was reopened on November 4, 1992.

Al-Fayha Railway Bridge - Near Basrah
The six pre-stressed concrete side spans and the two continuous rotating navigational steel spans suffered considerable damage. The steel spans are of truss construction of length 78 m. The direct hit to the supporting 12 m diameter, 14 m high hollow central pier caused the pier to topple with the steel span resting on the collapsed pier and one end pier. The other end dropped 8 m from its proper position. Several key elements were seriously damaged. One concrete span had also suffered a lateral shift of 1.75 m. Large diameter bored piles under one pier were displaced as much as 2 m from proper position.

100 m high R.C. Chimney for an electric power plant
The chimney suffered two missile hits, one at 50 m height causing a 3 m dia. through hole and the other just above foundation level causing a similar hole and serious damage to supporting foundation piles. After careful analytic and design consideration, a solution was formulated and fully implemented, thus saving the chimney from being demolished as had initially been recommended by others.

Boiler tower of a 320 MW unit in an electric power station.
The 47 m high steel skeleton houses the 3500 ton boiler which hangs from girders at the top. The piled foundation of the structure suffered a direct hit causing serious damage to the foundation system, buckling of several key columns and a tilt of the whole structure with a horizontal sway of 3.0 m at the top. Because the boiler and the many kilometers of pipework have remained largely intact, the task presented has been to straighten up the structure, strengthen or replace its buckled members and introduce new piled foundations underneath, all without dismantling the boiler. Formulation of the solution strategy presented an engineering challenge of unparalleled magnitude. The solution that evolved embodied innovations not only in analysis and design but also in devising methods of control of forces and displacements during the lifting and restoration process. Implementation of the solution was successfully completed in September 1995.

Baghdad Suspension Bridge (336 m long).
Participation as a member of the technical consultative board for the reconstruction of the largely destroyed bridge.