Building Industry and Earthquake Damage in the Arab region

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Earthquake damage to structures in the Arab Region is a subject of great concern. It urges continual improvement of design standards for future constructions , also searching methods to protect our treasures of multi civilizations inherited structure s:

- **Modern Construction** : Usually are built of one and up to four storey reinforced concrete framed structures.

  In large cities twelve and also up to twenty storey are less common and less popular for housing. Of course few high rise commercial buildings also exist.

  The buildings are designed (Especially where Seismic Loading and related recommendations are concerned), according to codes derived mainly from : The American Society of Civil Engineers Unified Building Code. This code and in its statement about variation in Material properties (Item 17.1.1) has emphasized the necessity to consider variation in Seismic Isolators due to aging.

  This statement and because the word “maintenance” in our region is not reliable and trustworthy, made Engineering Authorities to not specify using Isolators in modern structures.

  Its felt however that knowledge about this technology its advantages and feasibility are required to compare with using rigid reinforced concrete frames which are felt to be too rigid that amplifies the earthquake effect, by causing severe cracks at plastic hinge location and damaging shocks to the contents of the buildings and both features require considerable maintenance after earthquake.

  Having read and reported to our Engineering Institution about the survival of the university hospital (University of California) and its delicate contents from the 1994 North Bridge Earth Quake and also other examples like the largest base isolated building in the world (Tohoku Electrical Company Building), It is thought that my presence in this workshop will convey and update to Engineering Institutions additional knowledge about this technology especially relating to cost and methods of application and maintenance.

- **Old Stone Construction:** Common houses were usually built as one storey high walls of soil originated material and rubble. Roofing were made by wood or stone rafters covered by sheeting which supported tamped soils.

  As for temples, castles and palaces left to us by different civilizations they were mainly built of stones and on natural protecting locations (hills or mountains tops and sometimes in natural caves).

  These structures and due to nature attacks as wind, rain, temperature variations and above all earthquakes are always a cause of worry and require constant precaution, restoration and also fortification measures.

  Examples of such measures that we were involved in design and construction management are those structures that I am going to briefly demonstrate:

  Maaloula Monastery

  Kadmous Citadel

  Salamon Citadel

  Azm Palace

  Markab Citadel

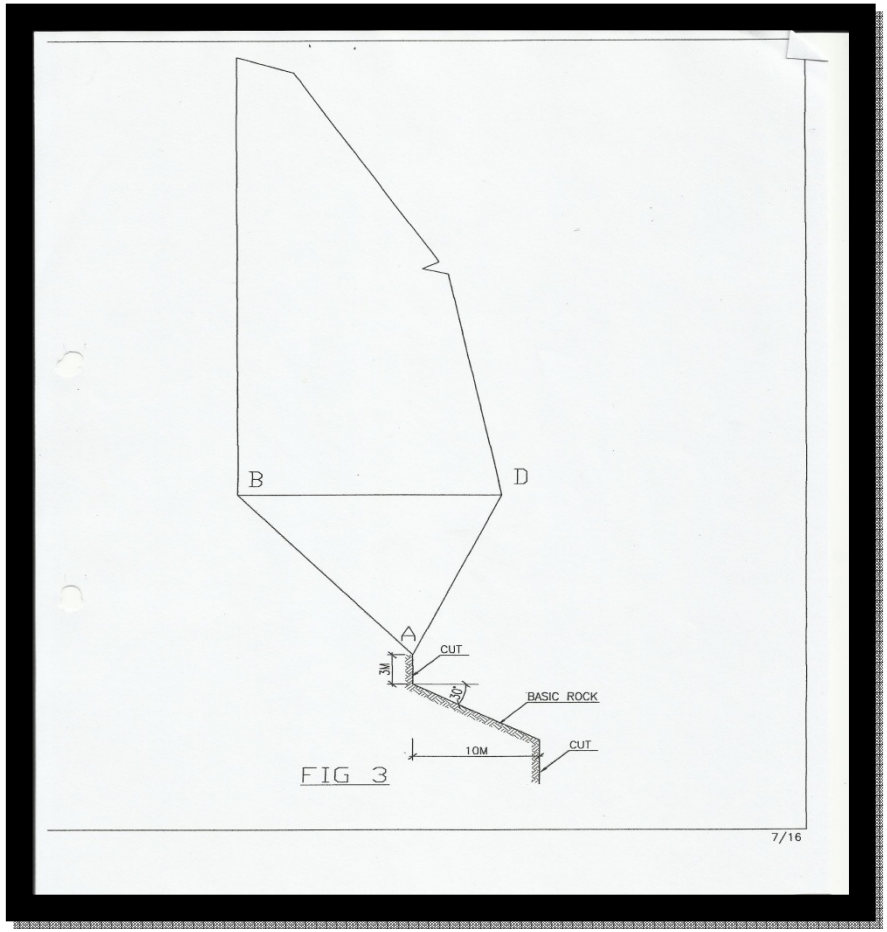
Maloula Monastery

Since Christianity shined from Nazaret, Maaloula Christians built their first church in a mountain cave.

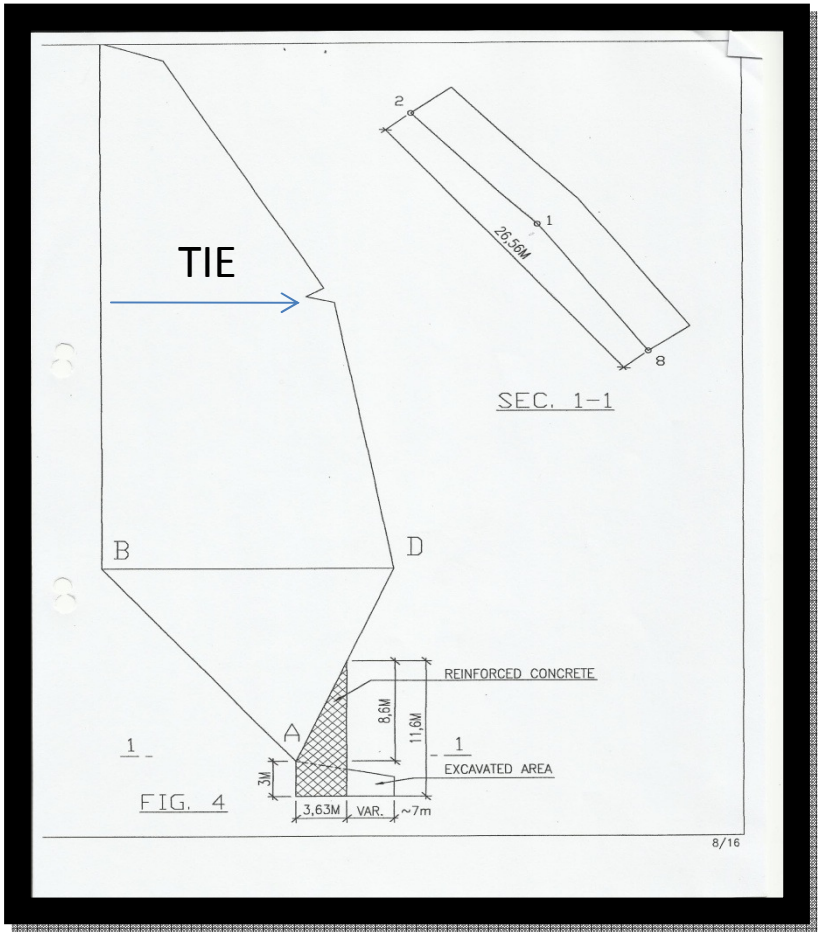
Pre historic E.Q caused the fall of a giant rock. The sister rock has apparent cracks causing everybody to fear a disastrous fall.

Maloula Monastery

The Crack was surveyed and traced as shown.

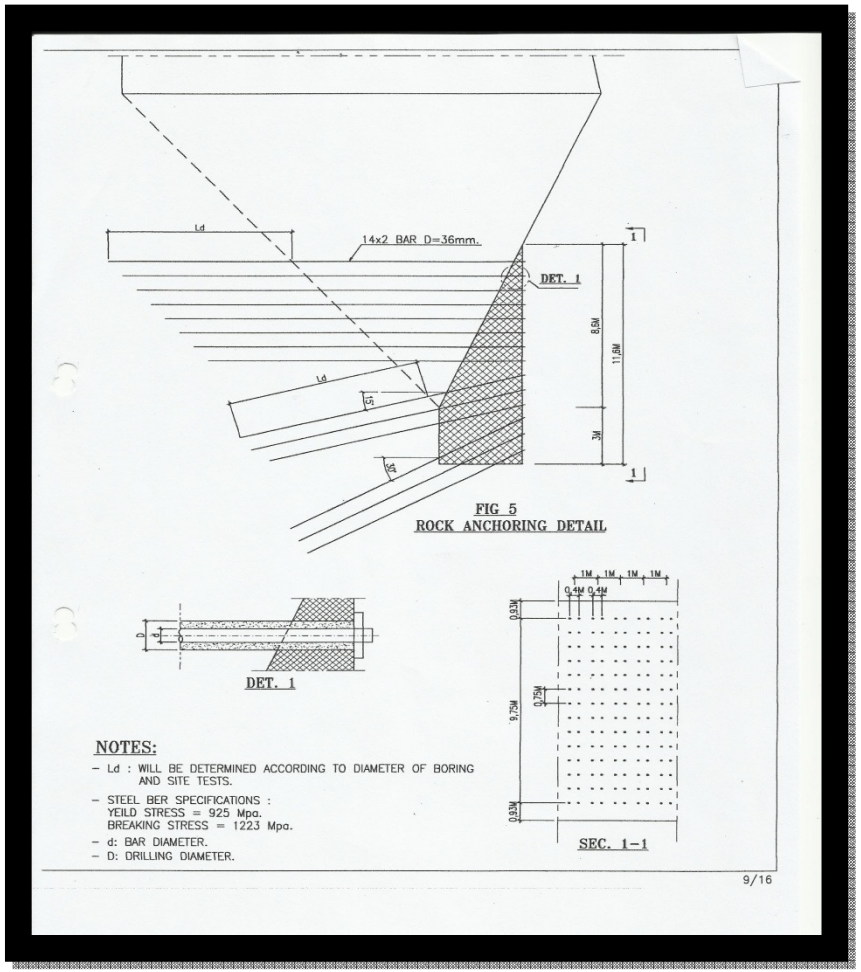


The mass of 30 000 tons and a horizontal force of 10 percent was applied at the rock center of gravity.



Maloula Monastery

A nailed Buttress and a tie at the top were designed to support a possible sliding of the Giant Rock.



Kadmous Citadel

A refuge of an old rebellion leader constructed the castle on top of a cliff.

The cliff fell as a result of an E.Q on houses located down the hill, whose residents belonged to a certain religious sect. It was feared that the residents might assume the fall was initially created by residents of the other sect who lived uphill.

Kadmous Citadel

We had to nail the rocks of the hill and construct a preventive wall.

By Shotcrete with steel Mesh reinforcement supported on the nails

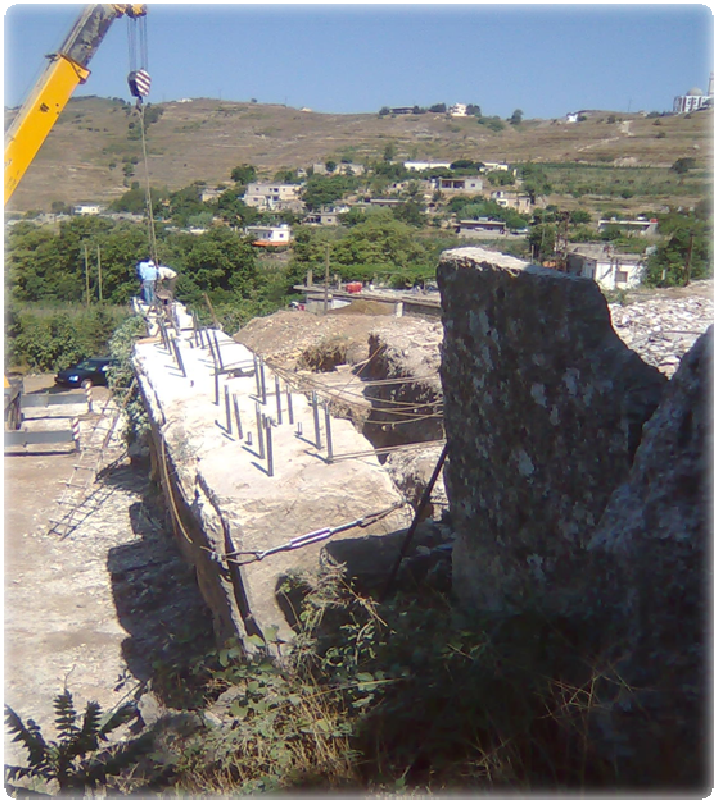
Salamon Citadel

Was built 2 centuries back using about 30 tons stones laid on top of each other to form walls.

As a result of a light earth quake few stones fell blocking the road.

Salamon Citadel

100 ton capacity crane had to be used to rebuild the wall using epoxy fixed lifting hooks.

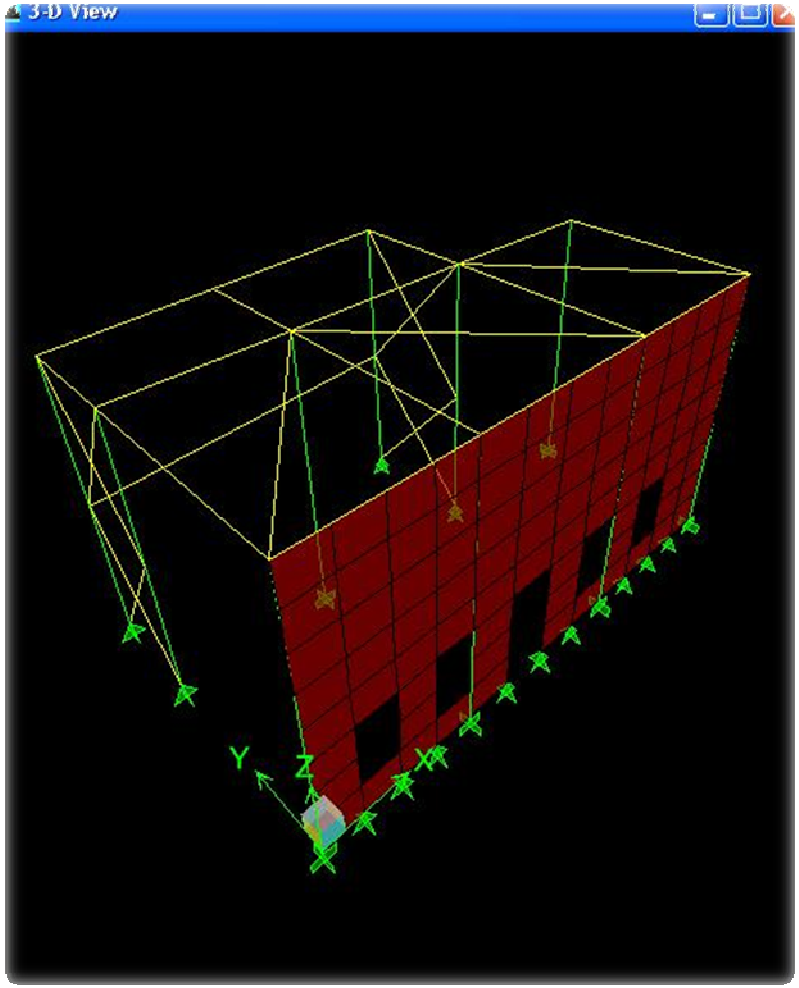


Azm Palace in Damascus

Built in mid 19th century of rubble stone and mortar with finished stone facing. No apparent resistance of lateral forces and because of relatively high (7 m high) one storey construction lot of cracks appear on the walls.

Azm Palace in Damascus

We recommended constructing a roof truss and supporting vertical truss in the back yard to increase lateral resistence.



Markab Crusade Citadel

Built on a hill through the ages was subject to natural erosion, created worries of a fall down.

Thus initiating the need to constructing slope stability aids for additional protection.

Markab Crusade Citadel

Slope stabilization by constructing a protecting retaining wall and nailing loose stones forming the slope under the castle.

- Protecting our heritage has always been costly using traditional methods. Any proposal to protect our and the humanity heritage will highly be appreciated for future generations.