

Learning from Structural Disasters

*Doctor's mistakes are buried,
but Engineer's mistakes become monuments*

The role of the engineer is to create a structure to perform a given function, based on a certain set of guidelines or specifications. The design of the structure should be carried out such that it performs its function throughout its life period.

Engineering failures are referred to as an engineering "disaster" based on the loss it has caused to the property, life and the environment.

By an analysis of engineering disasters, modern engineering designers can learn what not to do and how to create designs with less chance of failure.



TACOMA WASHINGTON BRIDGE DISASTER

The Tacoma Narrows Bridge is a pair of mile-long (1600 meter) suspension bridges with main spans of 2800 feet (850 m). The first bridge, nicknamed *Galloping Gertie*, was opened to traffic on July 1, 1940, and became famous four months later for a dramatic wind-induced structural collapse that was caught on color motion picture film



APARTMENT BUILDING SPLITS INTO TWO,
FALLS SIDEWISE

It happened in the city of Liuzhou, China. Instead of collapsing straight down, the 22 story apartment building splits into two halves, with one half falling to the ground sideways (fortunately not causing a disaster or taking any lives) and the other half remaining standing on an angle that makes it look like the Leaning Apartment Tower of China



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What causes these disasters?

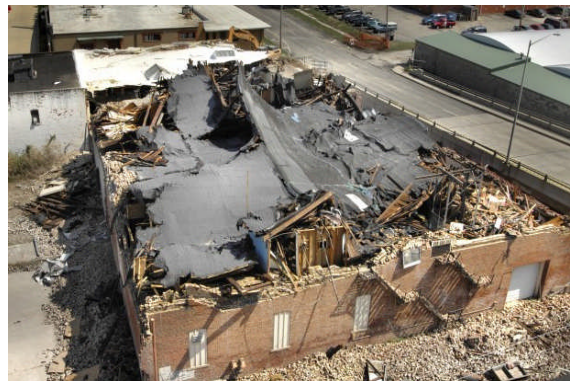
The primary causes of engineering disasters are usually

- human factors (including both 'ethical' failure and accidents)
- design flaws (many of which are also the result of unethical practices)
- materials failures
- extreme conditions or environments,
- combinations of these reasons



THE SAMPOONG DEPARTMENT STORE

The Sampoong Department store collapse killed 500 people. The building was originally planned as a 4 story office building. Then it was changed to be a department store, which entailed removing a portion of the structure to make room for escalators and an atrium. In addition, a 5th floor was later added, and the HVAC equipment was moved onto the new roof, severely overloading the structure.



WAREHOUSE AT BLOOMINGTON

A century old, three storey brick building at 317 S. Center St. collapsed, spilling rubble onto the center street bridge.



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In January 4, 1999, a pedestrian Rainbow bridge across the Qi River in the Sichuan province collapsed three years after it was built. The collapse of the Rainbow bridge led to 40 deaths and 14 injuries. Parts of the bridge were rusty, concrete used in its construction was too weak and there were serious welding problems.

RAINBOW BRIDGE, CHINA

How do we avoid these?

- ❖ *A qualified structural Engineer/organization should be assigned to do the structural design.*
- ❖ *All the possible loads coming on the structure should be visualized and all the possible load combinations shall be applied while designing.*
- ❖ *A structural Engineer shall also consider the practical feasibility of the design.*
- ❖ *Preparation of the design document should be given priority.*
- ❖ *Structural designs should be proof checked by experienced structural engineers.*



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METRO RAIL BRIDGE, INDIA

The failure of pier cap occurred due to inadequate prop / jacket. This was coupled with failure of cantilever pier cap due to inadequate development length of top reinforcement of the cantilever pier cap.

The cantilever pier cap which was behaving as a simply supported beam due to introduction of prop / jacket started behaving like a cantilever beam suddenly after failure of the prop which it cannot sustain (It was inadequately designed). So, the so called "cantilever pier cap" collapsed.

- ❖ *Reinforcement detailing should be given more emphasis considering the behavior of structural components and connections between components.*
- ❖ *Ductile detailing in the seismic areas should be given emphasis.*
- ❖ *Detailing of corbels, deep beams, cantilevers etc should be checked as per the codal provisions.*
- ❖ *Planning of the construction phases should be given importance.*
- ❖ *Deploying adequately experienced Engineer/ Supervisor for construction/erection supervision.*
- ❖ *Once construction is over, it is very important to prepare As-built drawings, the structural Engineer can refer to it in future, while making planning for extension etc.*



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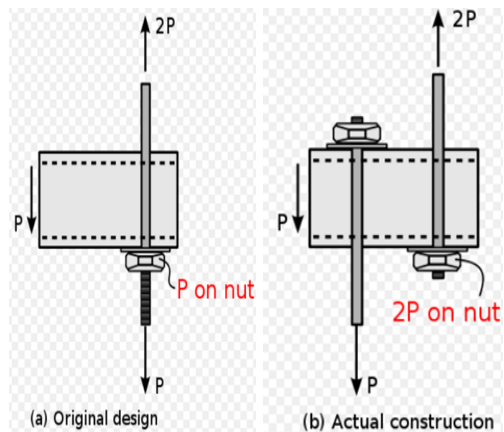


HYATT REGENCY WALKWAY COLLAPSE

The Hyatt Regency hotel walkway collapse was a collapse of a walkway that occurred on July 17, 1981, in Kansas City, Missouri, United States, killing 114 people and injuring 216 others during a tea dance. At the time, it was the deadliest structural collapse in U.S. history.

One of the defining features of the hotel was its lobby, which featured a multistory atrium spanned by steel, glass and concrete walkways on the second, third and fourth levels suspended from the ceiling. The walkways were approximately 120 ft (37 m) long and weighed approximately 64,000 lb (29,000 kg). The fourth level walkway aligned directly above the second level walkway.

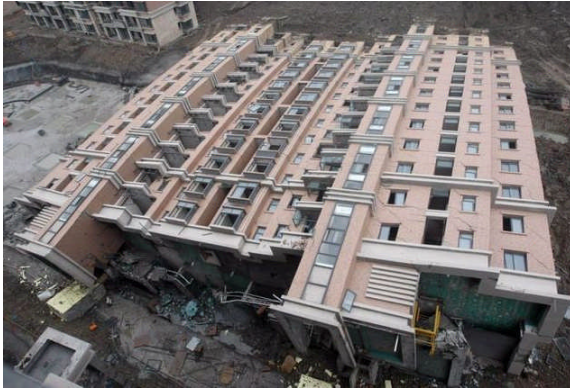
The fourth floor bridge was suspended directly over the



- ❖ *Preparation of structural steel shop drawings should be done by a qualified person rather than the fabricator doing it himself.*
- ❖ *Deviations if any from the original design shall be approved by the designer.*
- ❖ *Well designed connection details are very important.*
- ❖ *Erection shall be based on a well planned erection methodology.*



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SHANGHAI APARTMENT COLLAPSE

13-storey apartment building collapsed in Chinese city of Shanghai, which was almost finished. It fell without being destroyed, like a domino. It gives the impression as if the building was razed as a tree and was laid down. According to the official version, the reason of the building collapsing was the construction of the underground garage and the loose soil.

The main reason for failure is a tall pile of dirt next to the building. The dirt excavated for the garage compacted the soil, causing it to shift and damage the building's foundations so that it fell over. Heavy rains and cracks in a flood wall for a nearby river also suggest problems with the soil on the site

- ❖ *A proper study of the soil investigation report should be done before designing.*
- ❖ *Before excavating close to an existing structure, strength of the soil and other properties shall be studied. Retaining structures should be designed and installed for retaining earth. The activity planning has a vital role.*



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Three people were killed when their vehicles fell with the bridge into the Mianus River 70 feet below, and three were seriously injured. Collapse due to failure of the Pin and Hanger assembly supporting the span.

MIANUS RIVER BRIDGE ,USA

Five Portuguese and one Spanish national died near Almunecar on Spain's, after a 20-ton section of motorway viaduct fell from 80 meters onto workers below.



ALMUNECAR ,SPAIN



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Once failure observed, immediate measures shall be taken to strengthen it. Well qualified and experienced persons/organizations shall be taken into the task. Non rectifiable failures once noticed should be abandoned, evacuated and demolished at the earliest. Any modification to use a failed structure should be avoided.

Paradigm offers its services in the different areas of structural Engineering to build up safe and durable structures. Its field of services in Structural engineering includes.

- *Preparation of construction drawings from the architectural drawings.*
- *Preparation construction sequence drawings*
- *Structural Analysis, Design, preparation of design drawings and documentation*
- *Design of earth retaining structures*
- *Reinforcement detailing*
- *Structural Steel detailing*
- *Preparation of ASBUILT drawings*
- *Quantity Estimation*

Photographs and information from following websites were used for the preparation of this

- *en.wikipedia.org*
- *www.annation.com/vfr/archives/015212.html*
- *www.telegraph.co.uk/.../Nine-held-over-Shanghai-building-collapse.html*
- *www.centralillinoisnewscenter.com > News > Top Video*
- *www.travelandsnaps.com*
- *www.lumq.com/01/collapse_of_bridges/*
- *www.engineeringcivil.com/failure-analysis-of-mishap-at-dmrc-on-1*
- *www.matscieng.sunysb.edu/disaster/*

