Technical University „POLITEHNICA“ of **Timisoara**
Technical University “GHEORGHE ASACHI” **Iaşi**

Faculty of Civil Engineering

“Draft proposal for the classification of failure causes of civil engineering structures”

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Motto:

D. B. Steinman:

"Engineering failures are the price of progress. If we profit from the experience of these failures will not have been in vain."

1.INTRODUCTION

Experience and judgment, which play an important role in structural design, receive little attention in technical literature. Technical literature concerning the failures of the past is rare; engineers do not wish to discuss their mistakes. Full discussion of failures can be useful, as presentations of great achievements.

Structural failures do not always mean collapse.

Generally, the collapse or the rupture of the structure may occur when:

- some of the principal structural members or connections fail
- as a result of fatigue after a large number of alternating stresses
- buckling of the main members
- severe blast or impact

1.INTRODUCTION

Structural failures can be caused by unsatisfactory material, fabrication or erection errors, faulty design.

Frequent causes of structural failures are:

- foundations movements
- connections fail
- incorrect appraisal of the buckling strength
- lack of adequate bracing
- overloading
- fatigue

1. INTRODUCTION

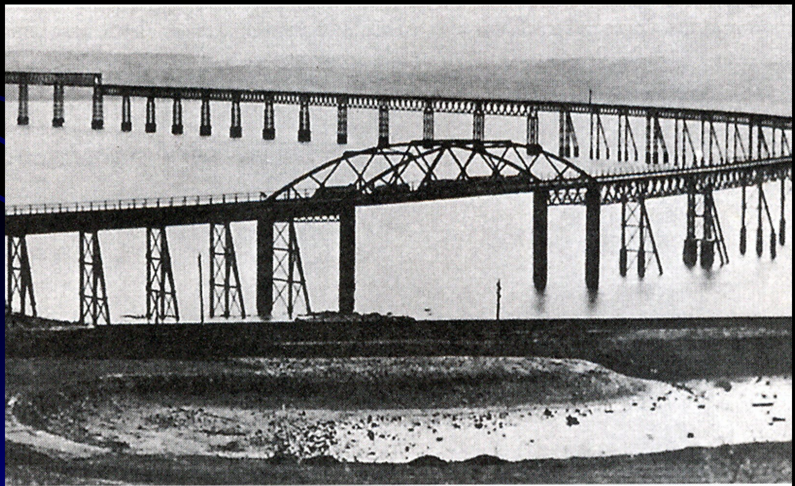
- The computation of an isolated compression member with known condition of loading and support is relatively a simple problem; when the element is considered as a whole, is difficult to establish the effectiveness of the stiffeners and bracings, the rigidity of the end supports, the load eccentricity etc.
- Overloading can occur as a result of changes in the use of the structures. For example, in the last decades, the traffic on bridges becomes heavier and denser.
- Buildings converted from one destination to another (frequently in the Eastern Part of Europe, after the political changes) are often overloaded. In these cases, an investigation of the existing structural safety is necessary.
- The experience from failure of different constructions provides a valuable knowledge base and gives an overview of the reliability of these structures.

2. Review of some typical failures and their causes

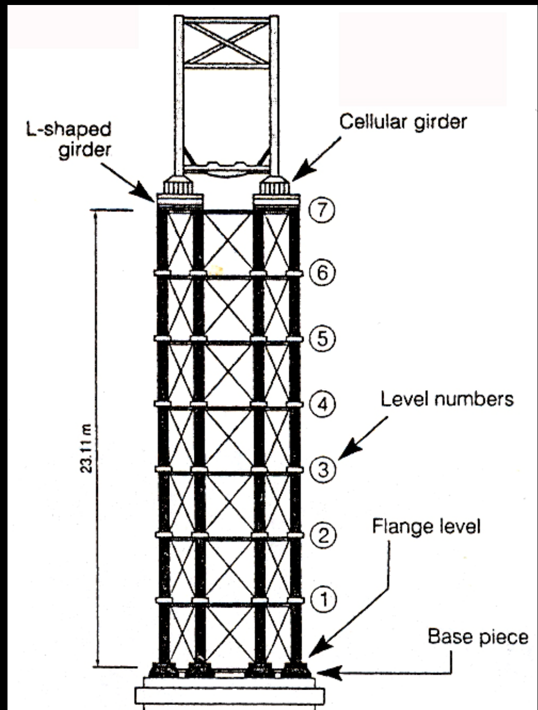
To establish a classification of failures is difficult; nevertheless some principal causes and typical examples can be pointed out:

Overloading (incorrect appraisal of the initial loadings) – in a general classification, 28 % of the cases can be ranged in this category.

1.5 kN / m²



The first Tay Bridge before failure



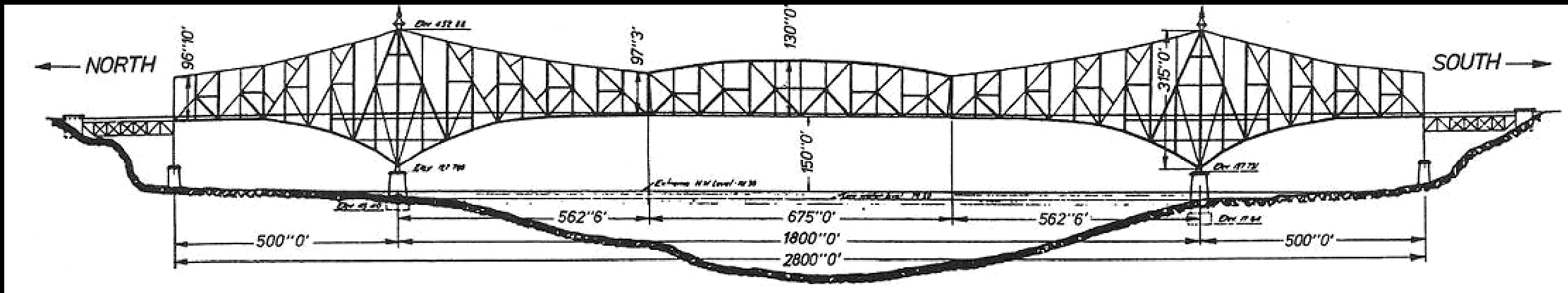
Typical bridge pier of the navigation channel

2. Review of some typical failures and their causes

Romanian Danube bridges in Festesti – Cernavoda
Anghel Saligny the designer of the structure took a value of
2.0 kN / m²

2. Review of some typical failures and their causes

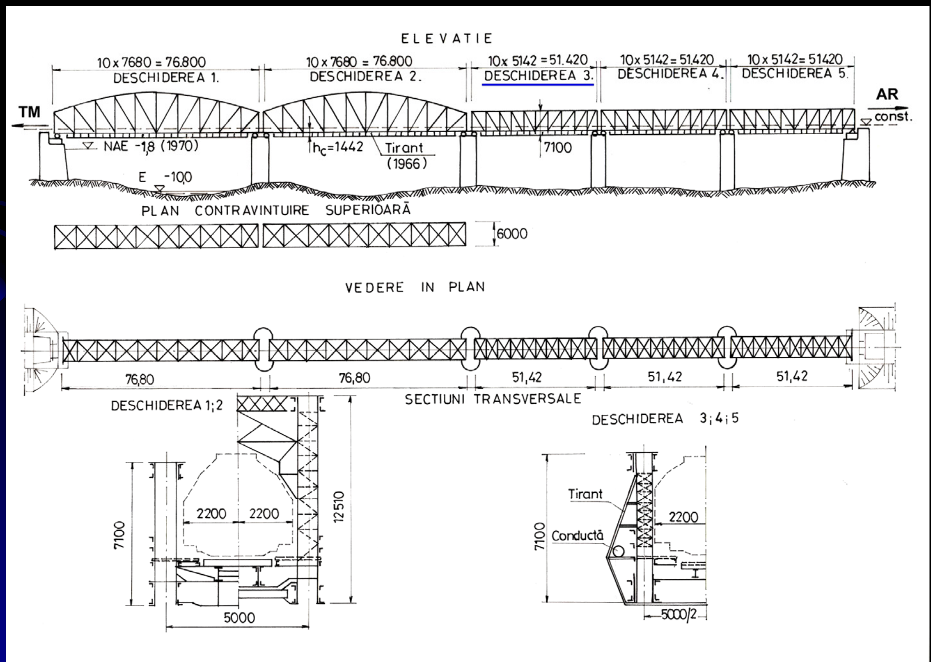
Design errors. In a general classification, 18 % of the cases can be ranged in this category. Design codes are more than 100 years old, but design errors are still frequent.

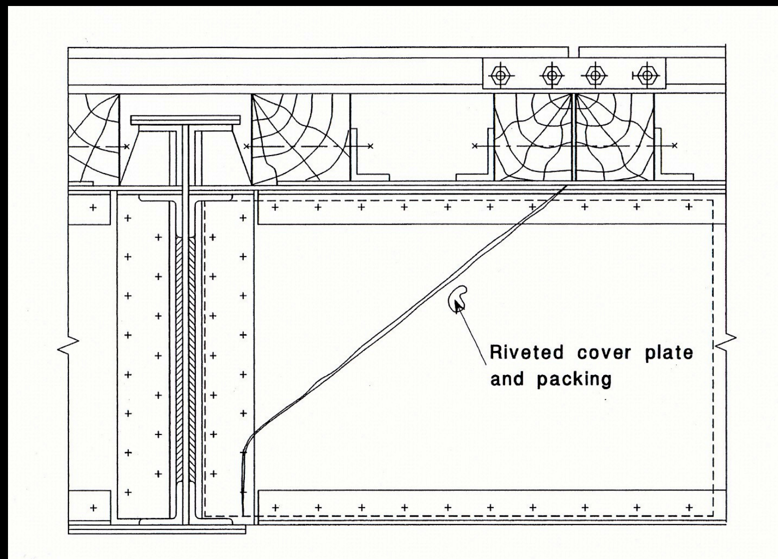


GENERAL ELEVATION OF THE DESIGN PROJECTED BY THE PHOENIX BRIDGE COMPANY.

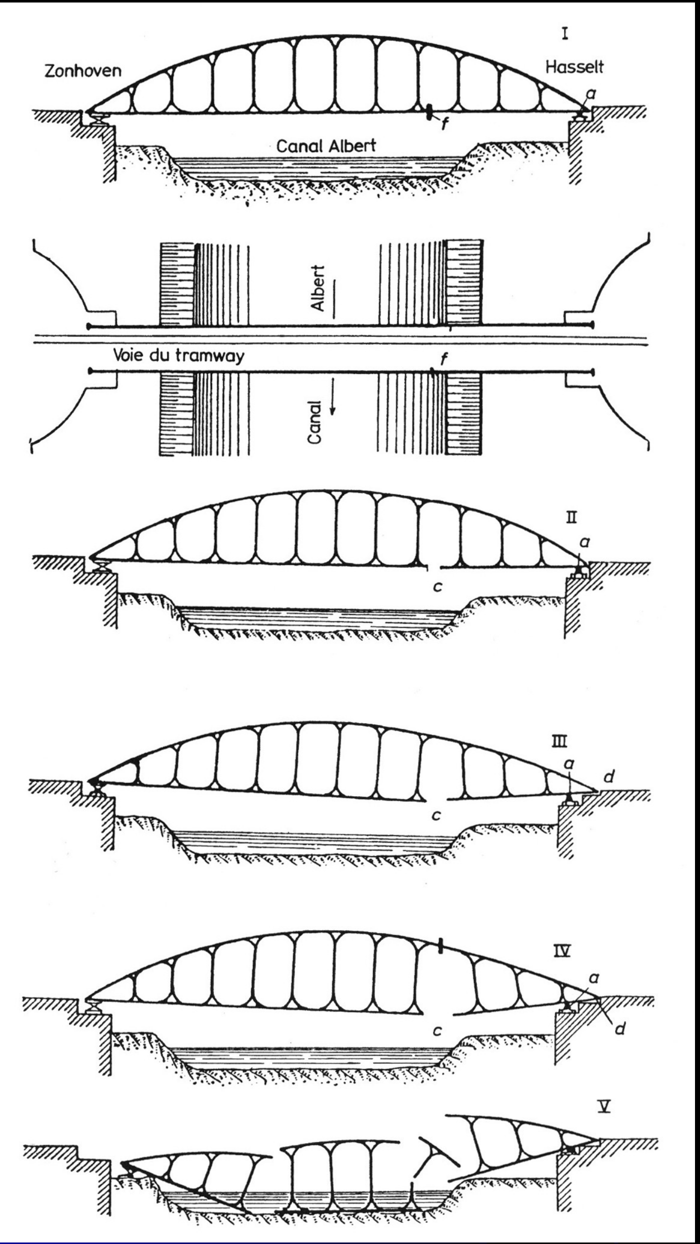
2. Review of some typical failures and their causes

Insufficient knowledge of the material qualities.
Approximately 18 % of the cases belong to this category, but probably these are the most frequent cases.
Fatigue failure is an old enemy; cracking due to fatigue is responsible for some major catastrophes .



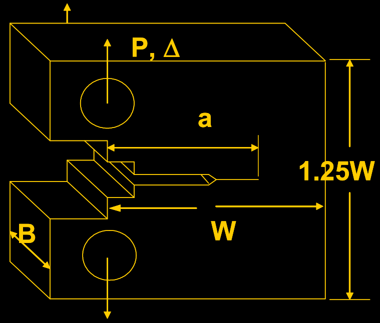


2. Review of some typical failures and their causes



The use of fusion welded structures introduced new uncertainties about fatigue behavior. One factor that affects the fatigue performance of welded joints is the presence of residual tensile stresses.
One of the most known examples is the failure of the Hasselt Bridge in Belgium (1938) due to the embrittling of the Thomas steel

Fracture toughness is a major factor in determining the reliability of engineering structures. For steel, fracture toughness KIC can be measured using the ASTM test piece illustrated in Fig. 2.8; a good value of KIC for mild steel is about 200 MNm-3/2



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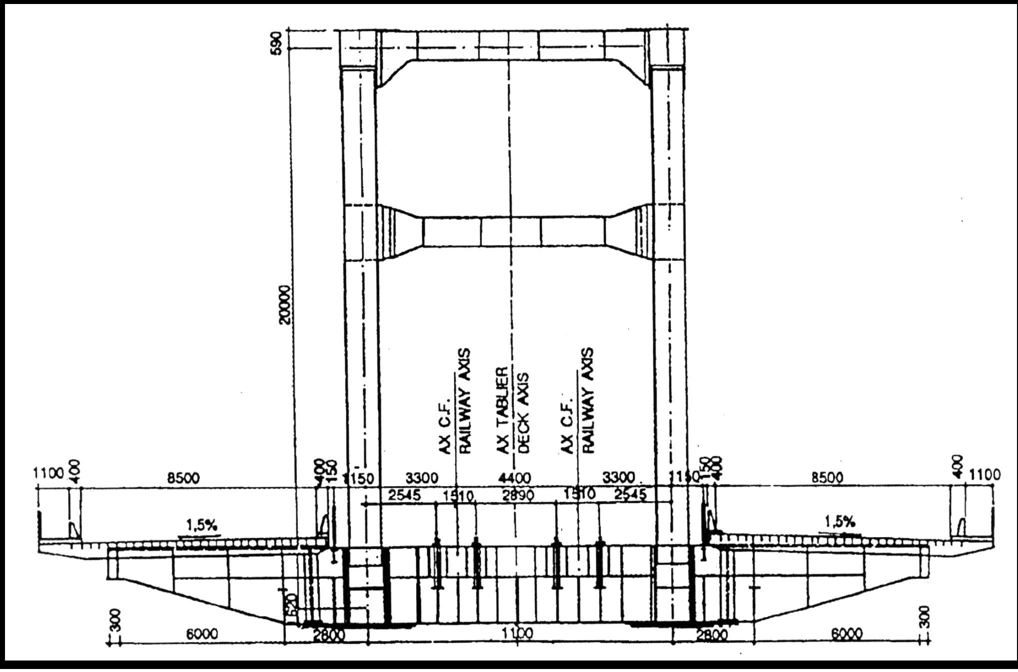
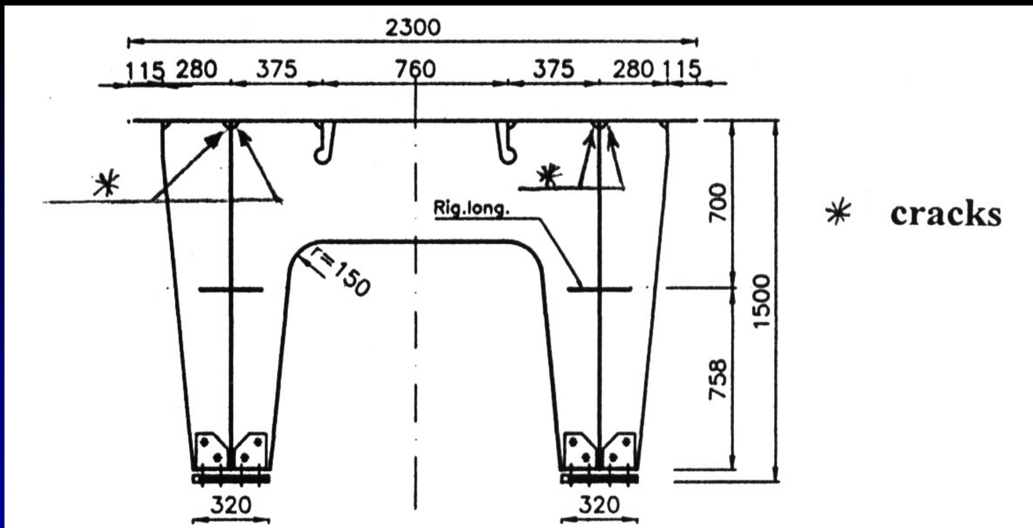
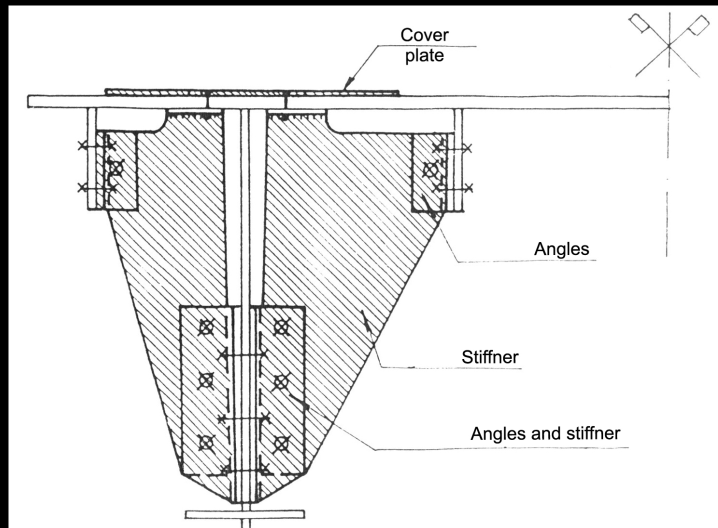
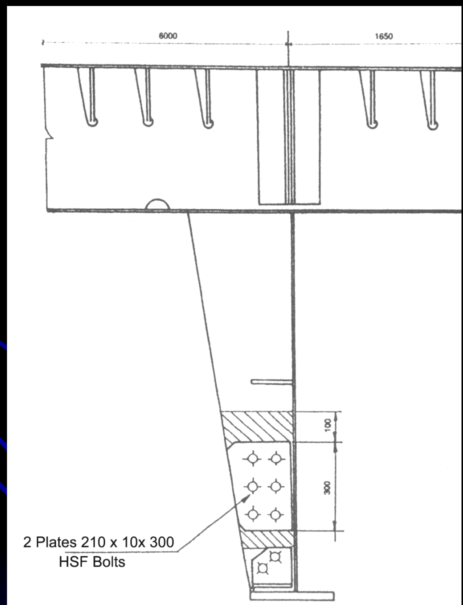


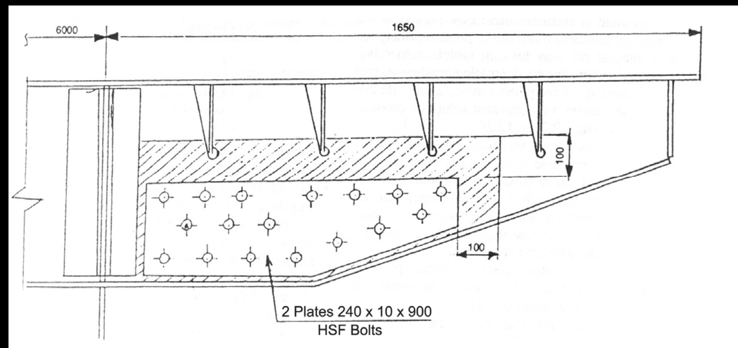




2. Review of some typical failures and their causes

Another source for failure is lamellar tearing. In many cases the contraction due to welding has opened up lamination in the steel in a region close to the fusion boundary. The primary cause of this type of failure is the presence of laminar sulphide inclusions.

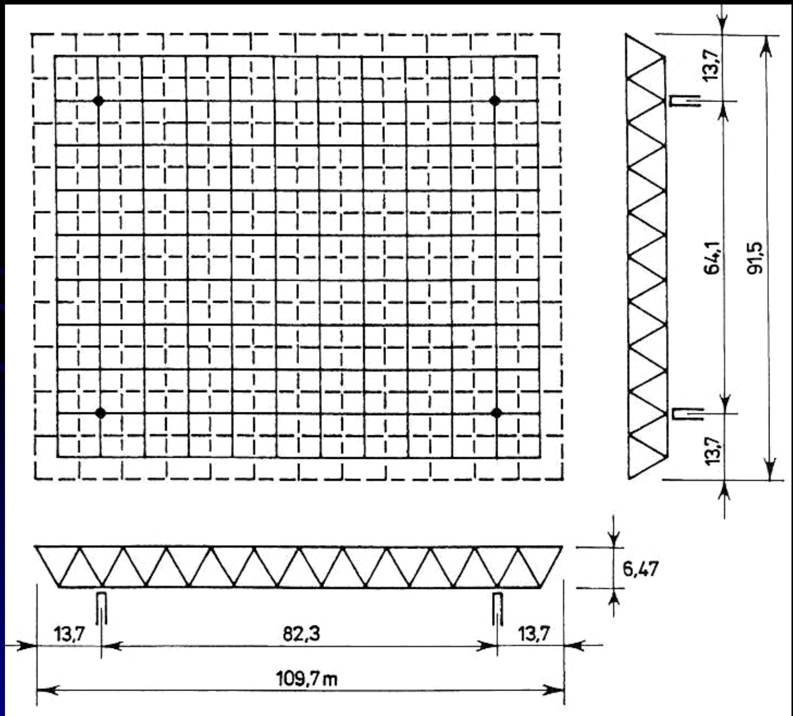


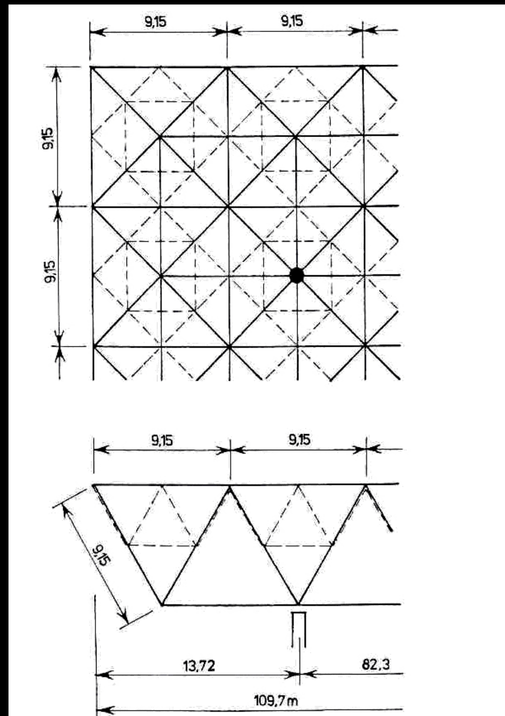


Elements → replaced or strengthened !

2. Review of some typical failures and their causes

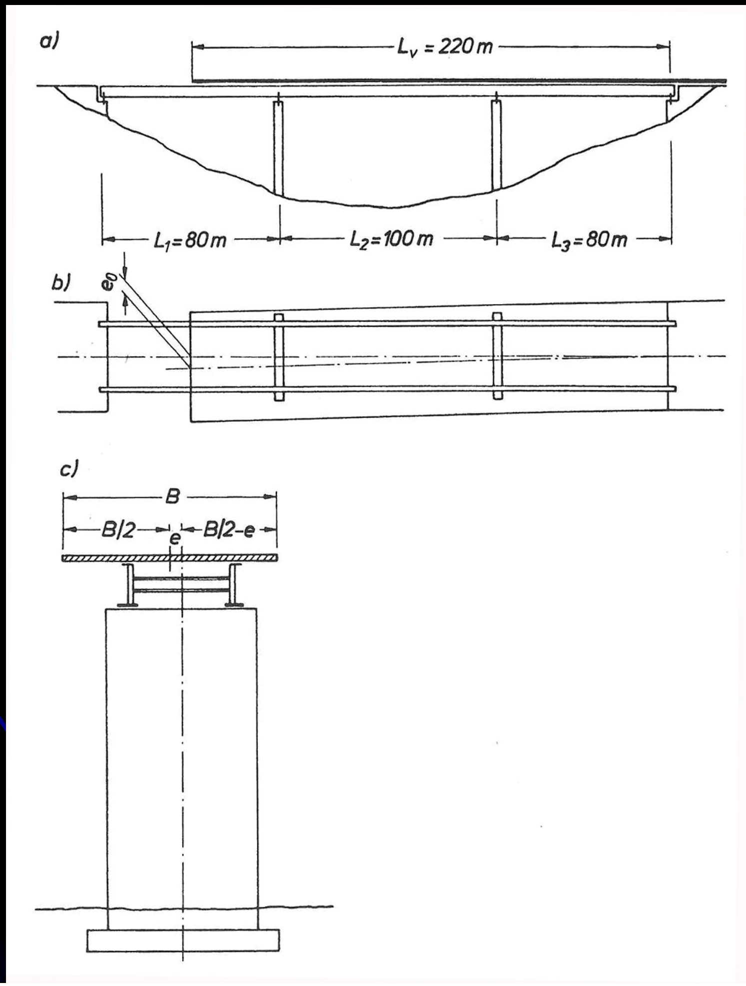
Errors in conception and details. Approximately 21 % of the cases belong to this category.
A typical example in this direction is the collapse of the Civic Center Coliseum, Hartford, Connecticut





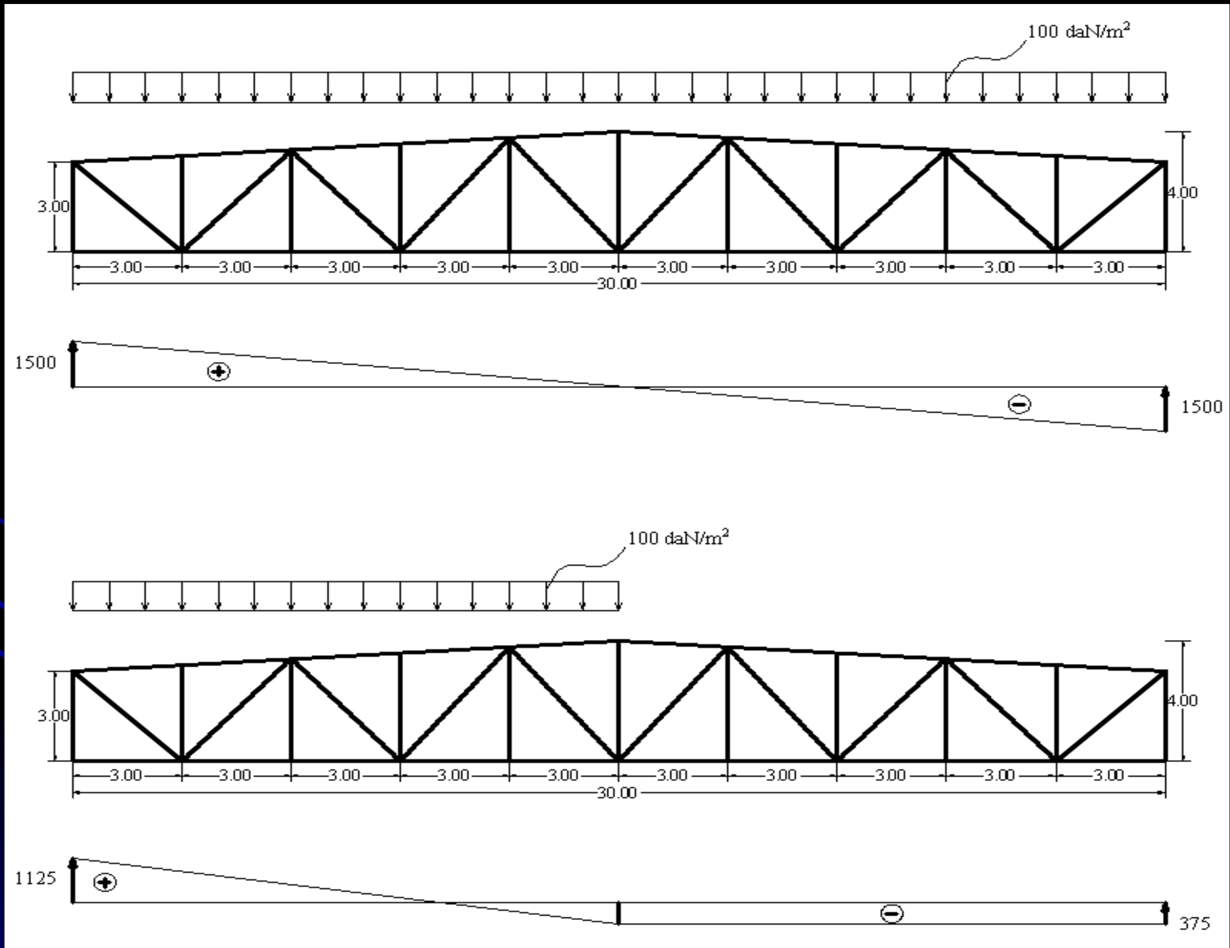
2. Review of some typical failures and their causes

Failures during the erection of the structure. A typical example is the Valangin Viaduct in Switzerland, which failed during the launching of the bridge deck



2. Review of some typical failures and their causes

Failures due to a lack of maintenance. In this category a large number of structures can be included.



2. Review of some typical failures and their causes

Terrorist attacks. In the last years another danger appeared: terrorism; this aspect must be separately analyzed.

[The collapse of the World Trade Center structures following the terrorist attacks of September 11, 2001 was one of the worst-ever building disasters in recorded history – killing 2749 people].

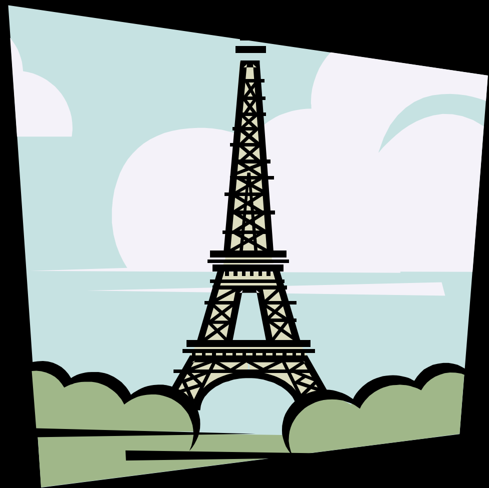
Buildings are not specifically designed to withstand the impact of fuel-laden commercial airliners. Building codes do not require building designs to consider aircraft impact.

Buildings are not designed for fire protection and evacuation under the magnitude and scale of conditions similar to those caused by the terrorist attacks of September 11, 2001.

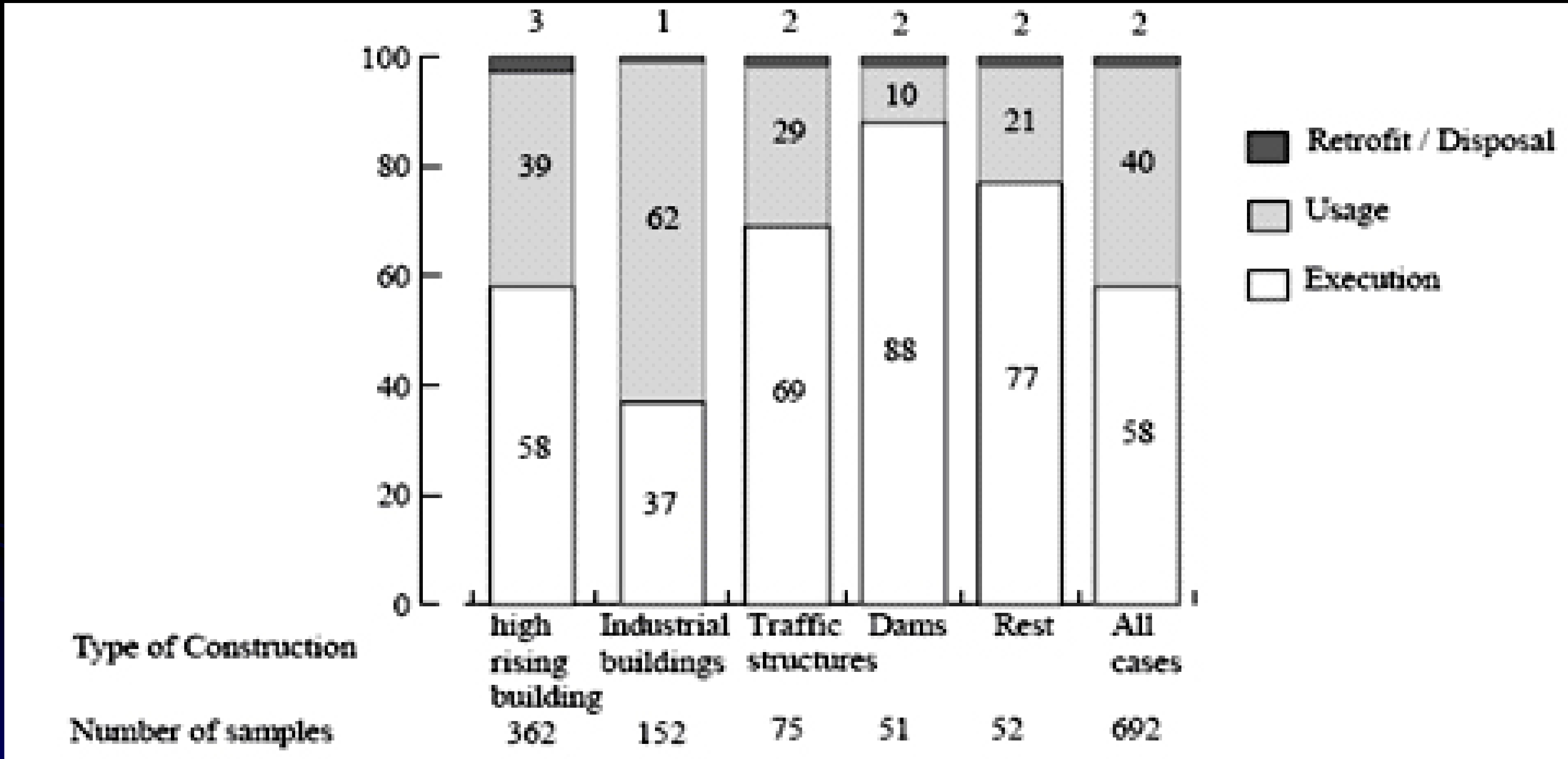
3 Classification of failures

A general classification is difficult. Some important studies exist in this direction. For a better analysis of failures causes, structures must be ranged in different categories, like:

- Buildings and bridges
- Dams
- Offshore structures
- Pipelines
- Nuclear power plants
- Chemical facilities



3 Classification of failures



The discovery moment of different errors is presented

3 Classification of failures

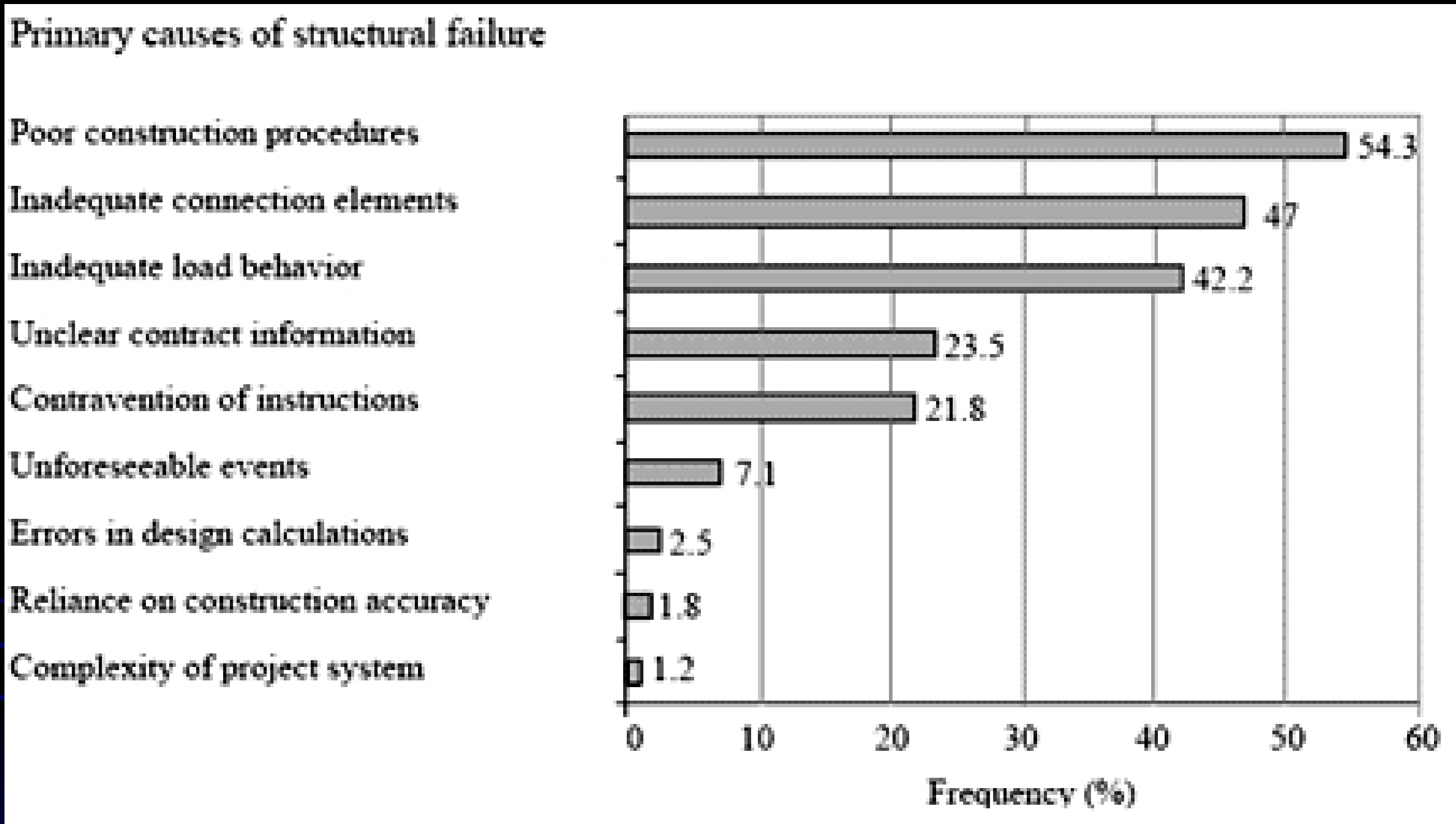
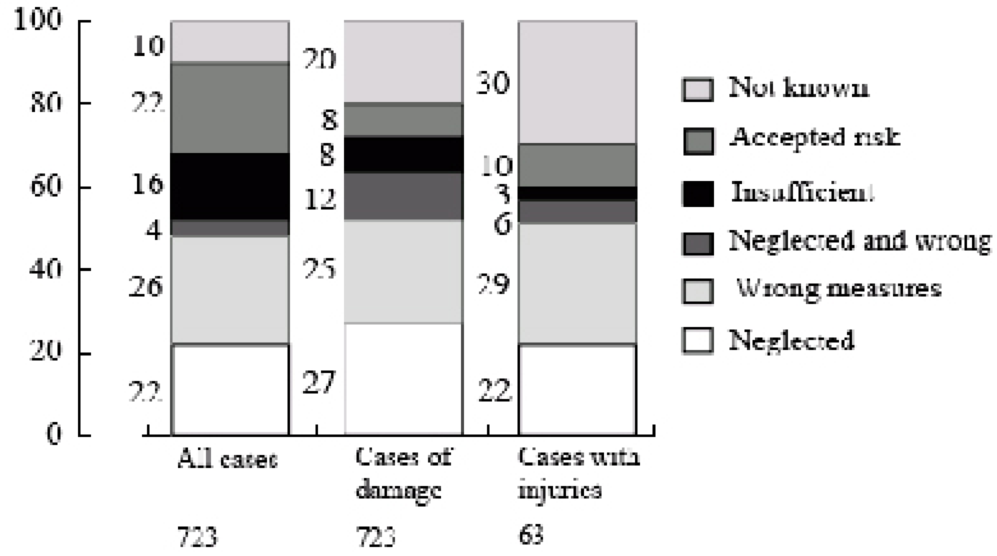
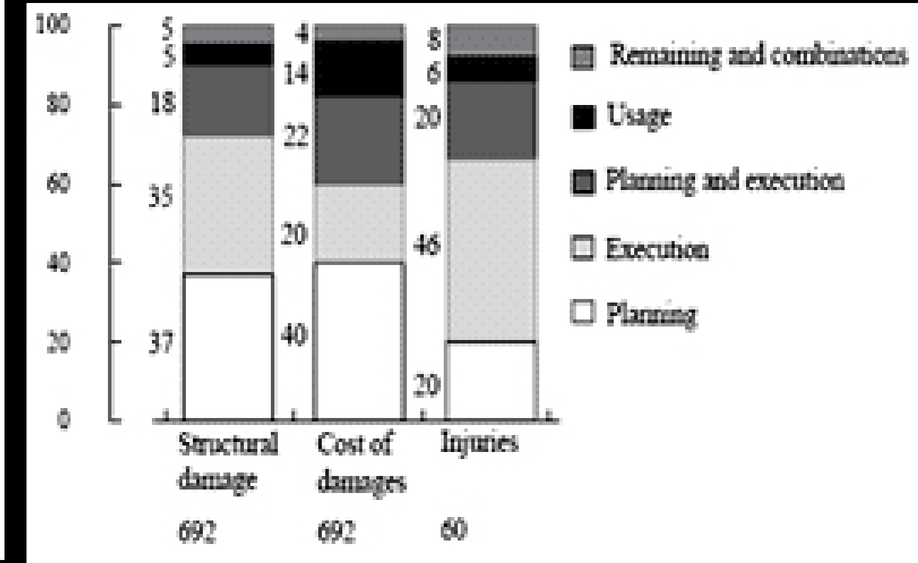


Illustration of primary causes of structural failures

3 Classification of failures

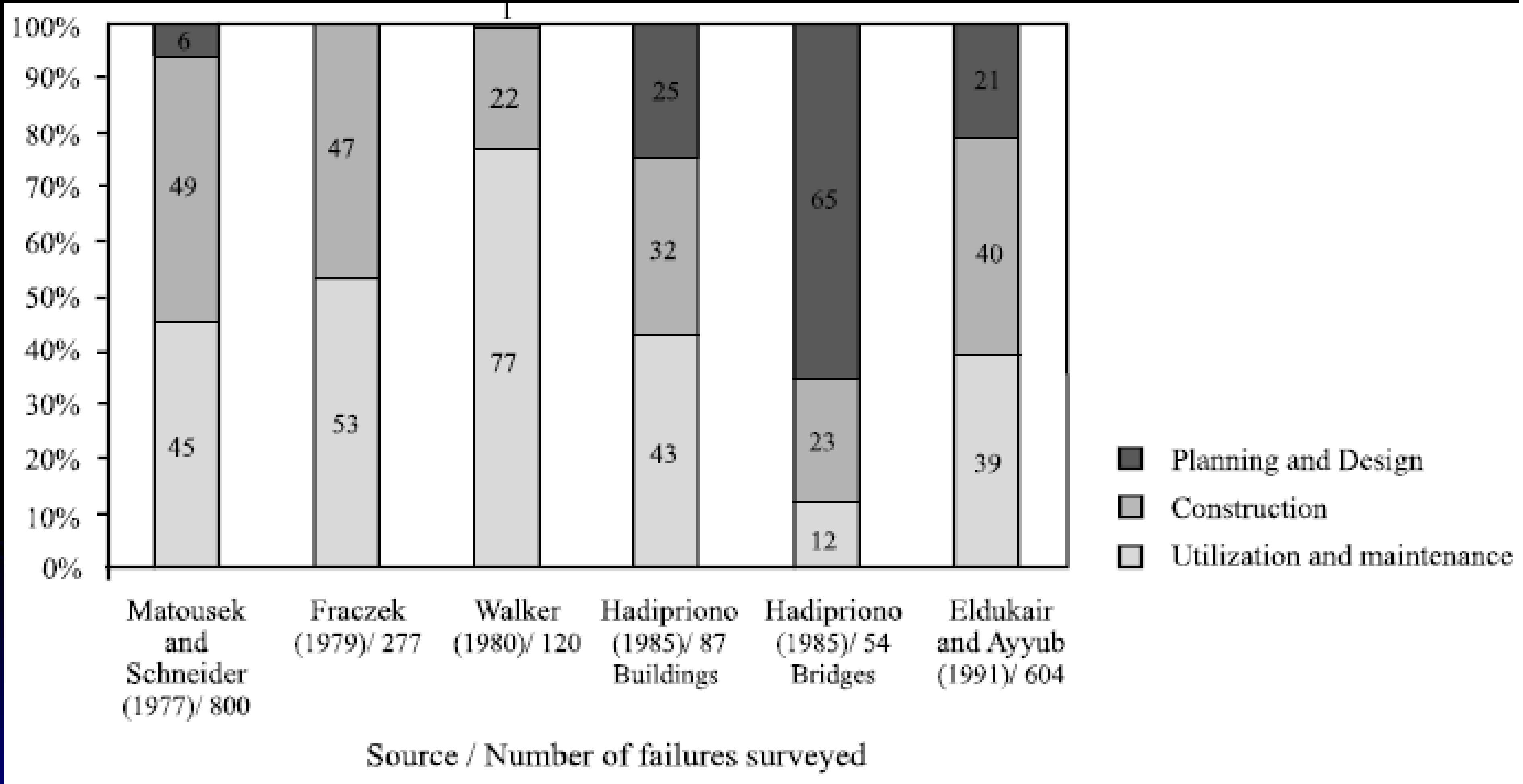




The relative distribution of reasons for failures and errors

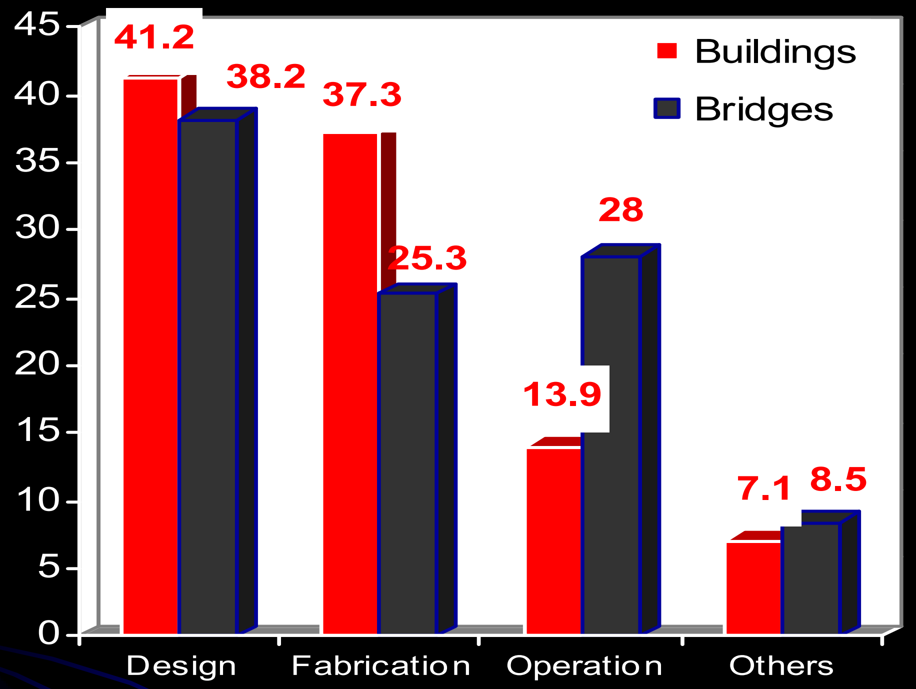
Relative distribution of when in the phases of the project failures and errors originate in inadequate treatment of risks

3 Classification of failures

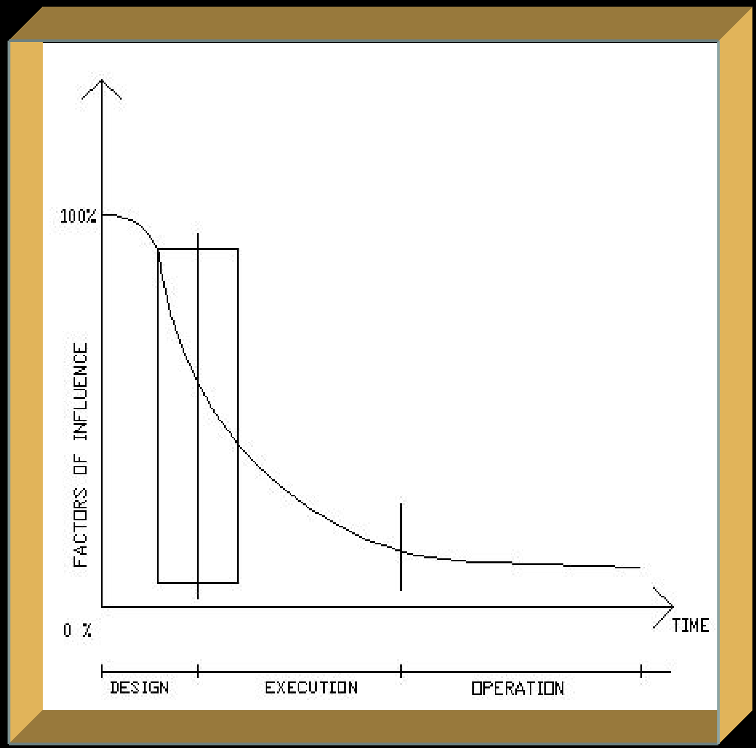


Relative distribution of failures and errors in the life-phases of building and bridge structures (Stewart and Melchers (1997)

3 Classification of failures



- Failures and damages in buildings and bridges



Analysis of the design phase

4. Proposal for the classification and analysis of failures

From the above analysis of different failures cases and the successive statistic presentation it can be seen that the problem is complex, the causes of failures are widespread . In order to analyze the failure mechanism in a modern way based on risk analysis, the structures must be classified in different categories like:

- Buildings
- Bridges
- Dams
- Offshore structures
- Pipelines
- Nuclear power plants
- Chemical facilities

4. Proposal for the classification and analysis of failures

It is important to specify from the beginning the material of the structure .A short description of the static system must be given.
The next step is to present the causes of collapses/deterioration and the consequences (loss of lives, injuries and damage costs).
The design codes must also to be specified.
Summarizing the following table can be conceived:

BUILDINGS					
MATERIAL	STATIC SYSTEM	YEAR OF CONSTRUCTION	CAUSES OF COLLAPSE MODES	CONSEQUENCES	DESIGN CODES

This proposal can be improved trough discussions during the meeting !

4 Proposal for the classification and analysis of failures

For some relevant cases (which will be chosen after an open discussion) a robustness analyses based on a unitary methodology will be performed and efficient means of robustness improvement can be proposed. Every participant country will nominate contact person which shall collect and present the relevant cases.

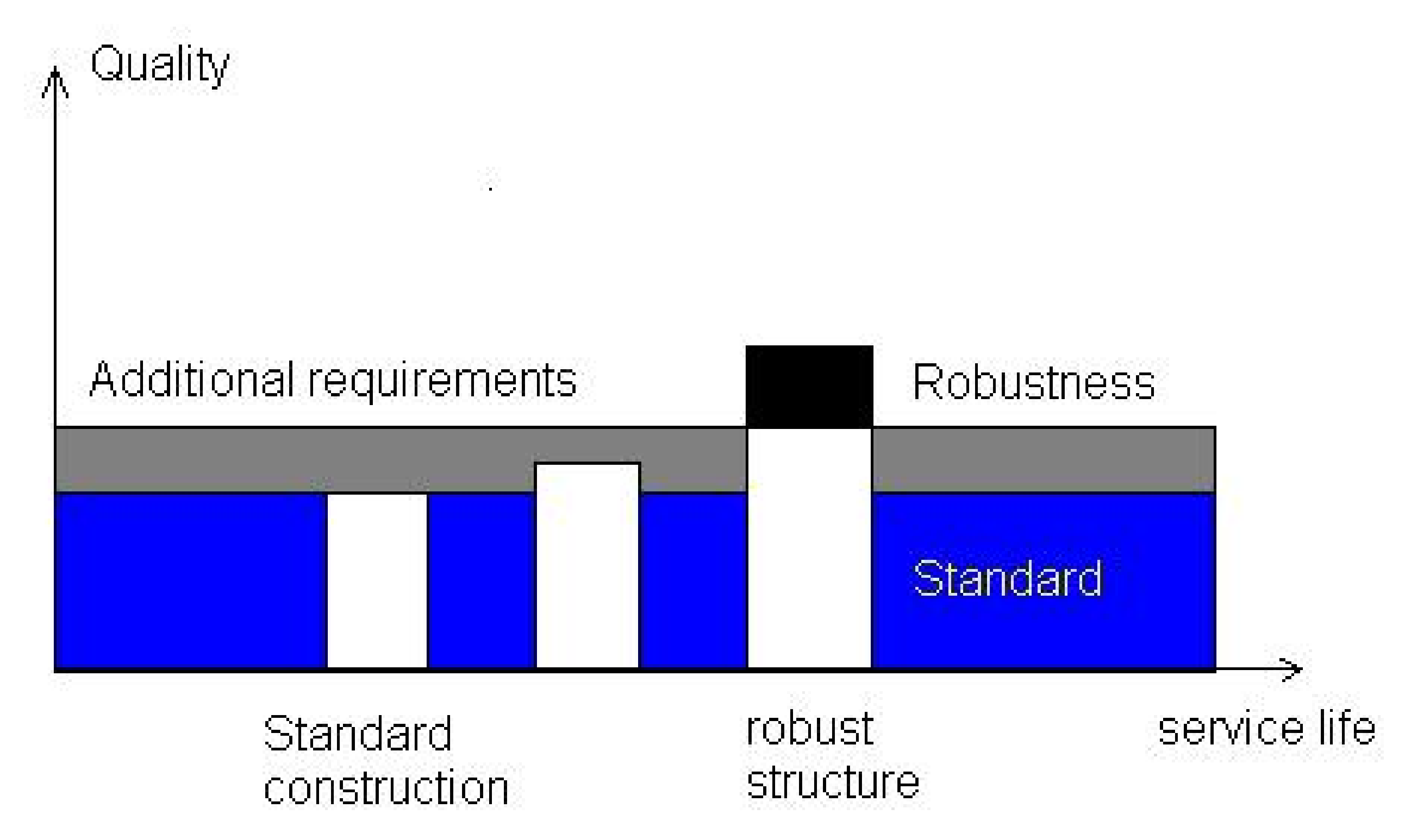
TIME TABLE

Nomination of the National responsible contact person 15.02.2008
Collection and systematization of different cases 01.05.2008
Selection of a series of relevant cases (cases studies) 15.05.2008
Robustness assessment, according to an accepted methodology
Proposals for robust improvement 01.07.2008

Responsible for buildings: Drd. Eng. Oana Ionita, E-mail: ionita@ce.tuiasi.ro
Responsible for bridges and other structures; Drd .Eng. Silvia Rominu, E-mail: silvia.rominu@ct.upt.ro

At the next meeting in Timisoara (September 2008) these selected cases will be presented and discussed.

Proposal for the classification and analysis of failures



In conclusion, to prevent all failures is not humanly possible. But if major disasters are to be prevented in the future, the lesson of each failure must be learned by all.


THANK YOU FOR YOUR
ATTENTION !