

Analysis and Design of Structures



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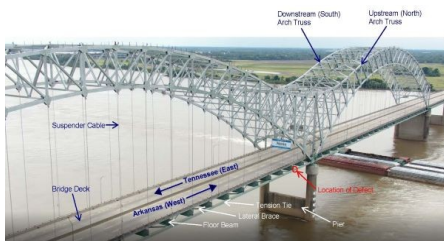
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The I-40 bridge connecting Memphis and the Arkansas city of West Memphis was shut down May 11 after inspectors found a crack in one of two 900-foot (275-meter) horizontal steel beams that are critical for the bridge's structural integrity.



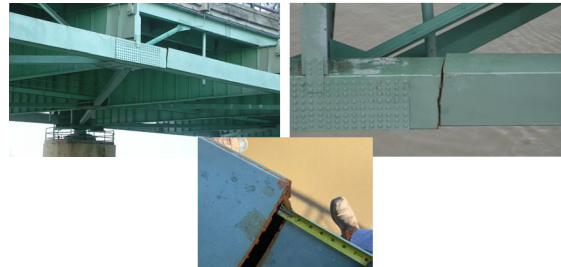
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This photo was pulled from 2019 drone footage, according to the Arkansas Department of Transportation.

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Hernando de Soto Bridge Repair Plans

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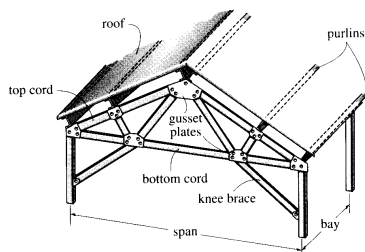
- The word **structure** has various meanings.
- By an **engineering structure** we mean roughly something constructed or built.
- The principal structures of concern to civil engineers are bridges, buildings, walls, dams, towers, shells, and cable structures.
- Such structures are composed of one or more solid elements arranged so that the whole structures as well as their components are capable of holding themselves without appreciable geometric change during loading and unloading.

Analysis and Design of Structures

- The design of a structure involves many considerations, among which are four major objectives that must be satisfied:
 - The structure must meet the performance requirement (**utility**).
 - The structure must carry loads safely (**safety**).
 - The structure should be economical in material, construction, and cost (**economy**).
 - The structure should have a good appearance (**aesthetics**).

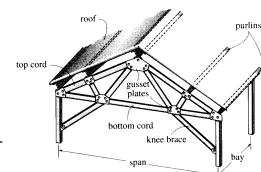
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- Consider, for example, the roof truss resting on columns shown below.



Analysis and Design of Structures

- The purposes of the roof truss and of the columns are, on the one hand, to hold in equilibrium their own weights, the load of roof covering, and the wind and snow
- Also to provide rooms for housing a family, for a manufacturing plant, or for other uses
- During its development the design is generally optimized to achieve minimum expenditure for materials and construction



Theory of Structures - Defined

- The complete design of a structure is outlined in the following stages:
 - *Developing a general layout*
 - *Investigating the loads*
 - *Stress analysis*
 - *Selection of elements*
 - *Drawing and detailing*
- These five stages are interrelated and may be subdivided and modified
- In many cases they must be carried out more or less simultaneously

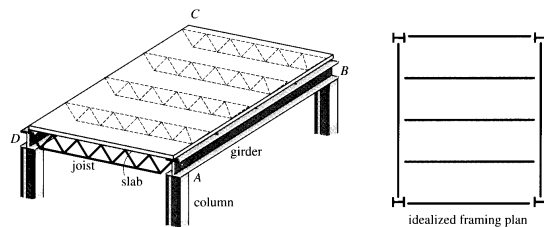
Theory of Structures - Defined

The complete design of a structure is outlined in the following stages:

(1) Developing a general layout

- The general layout of a structure is selected from many possible alternatives.
- This stage involves the choice of structural type, the selection of material, and a tentative estimation of cost based on a reasonable analysis of a preliminary structural design.
- It is clear that this stage of design calls for an engineer with a high order of experience, skill, general knowledge, and imagination.

Theory of Structures - Defined

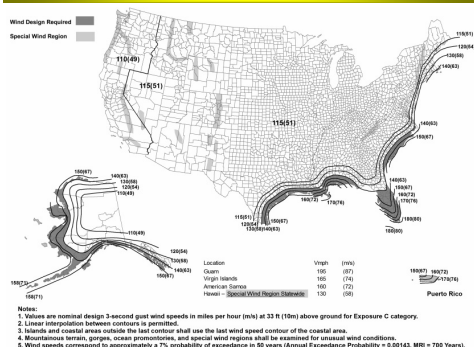


Theory of Structures - Defined

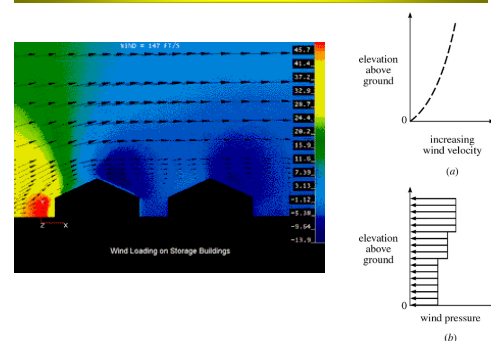
(2) Investigating the loads

- Before a refined structural analysis can be carried out, it is necessary to determine the loads for which a given structure should be designed.
- General information about the loads imposed on a structure is usually given in the specifications and codes.
- However, it is part of the designer's responsibility to specify the load conditions and to take care of exceptional cases.

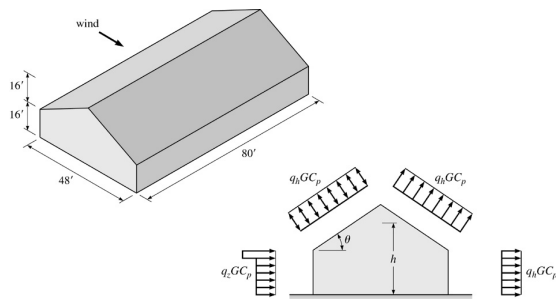
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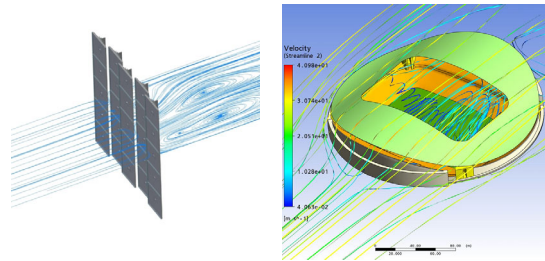
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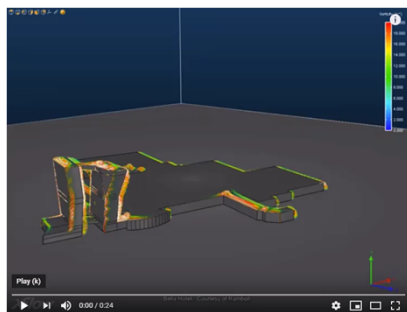
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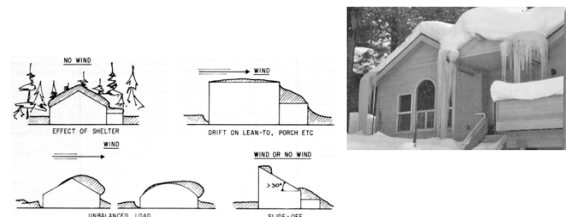
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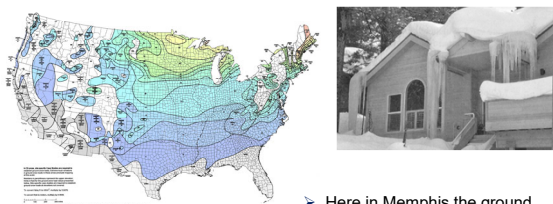
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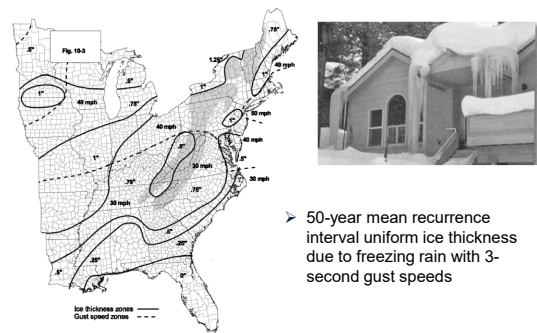


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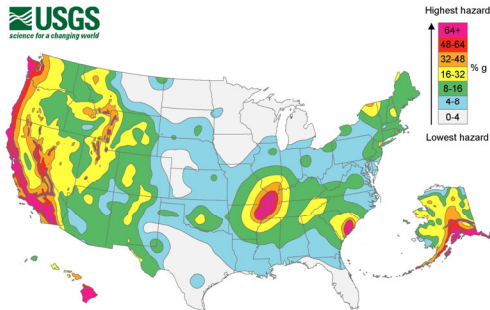
➤ Here in Memphis the ground snow load is 10 lb/ft²

Theory of Structures - Defined

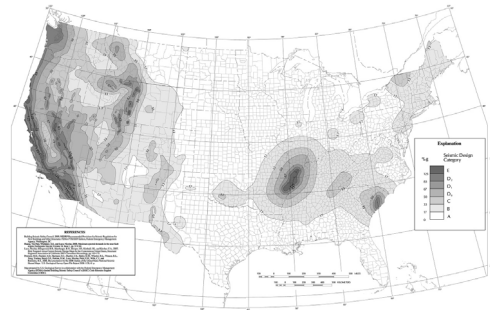


➤ 50-year mean recurrence interval uniform ice thickness due to freezing rain with 3-second gust speeds

Theory of Structures - Defined

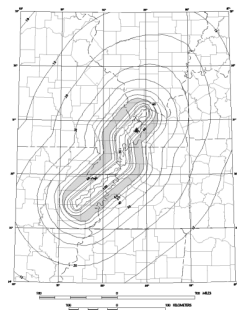


Theory of Structures - Defined



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- Maximum earthquake ground motion for United States of 0.2 (sec) spectral response acceleration

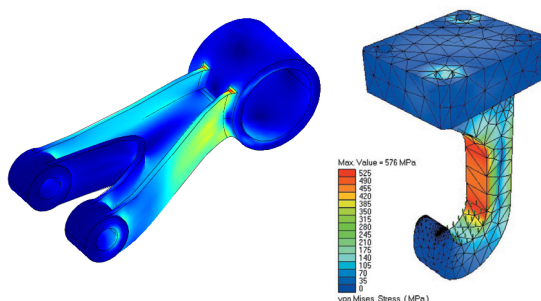


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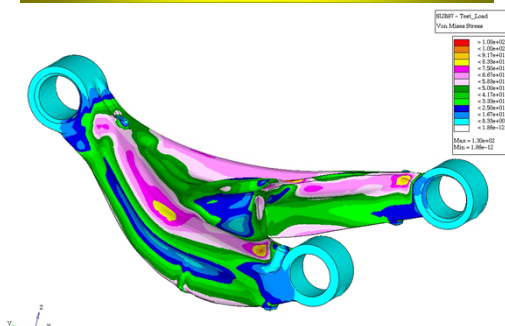
(3) Stress analysis

- Once the basic form of the structure and the external loads are defined, a structural analysis can be made to determine the internal forces in various members of the structure and the displacements at some controlling points.
- When live loads are involved, it is important to determine the maximum possible stresses in each member being considered.
- The principles governing this phase of design are usually discussed in the theory of structures.

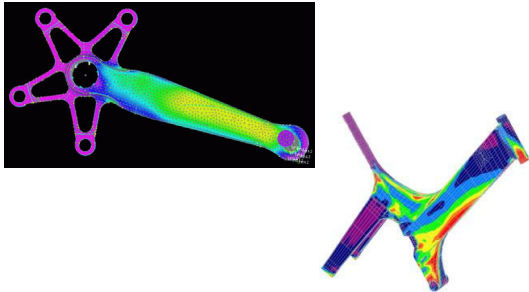
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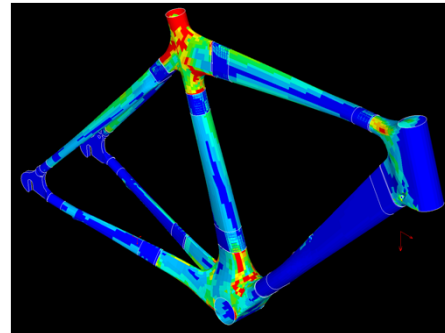
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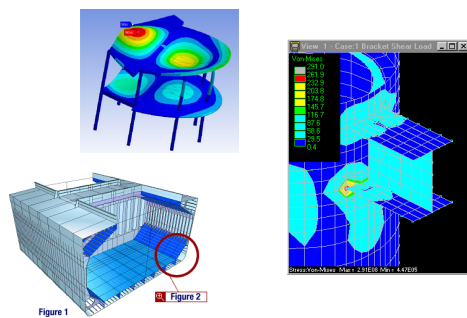
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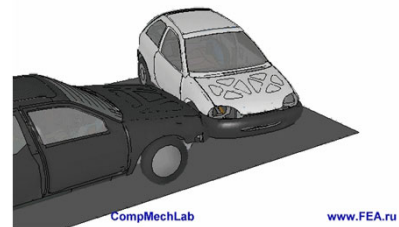
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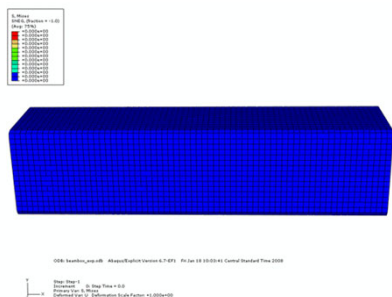
Theory of Structures - Defined



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Theory of Structures - Defined

(4) Selection of elements

- The selection of suitable sizes and shapes of members and their connections depends on the results of the stress analysis together with the design provisions of the specifications or codes
- A trial-and-error approach may be used in the search for a proportioning of elements that will be both economical and adequate
- A sound knowledge of strength of material and process of fabrication is also essential

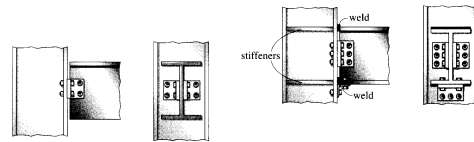
Theory of Structures - Defined



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(5) Drawing and detailing

This final stage includes the preparation of contract drawing, detailing, job specification, and final cost; this information is necessary for construction to proceed



Theory of Structures - Classified

Structural theories may be classified from various points of view. For convenience of study, we shall characterize them by the following aspects:

- Static versus dynamic
- Plane versus space
- Linear versus nonlinear structures
- Statically determinate versus statically indeterminate structures

End of Theory of Structures

Any Questions?