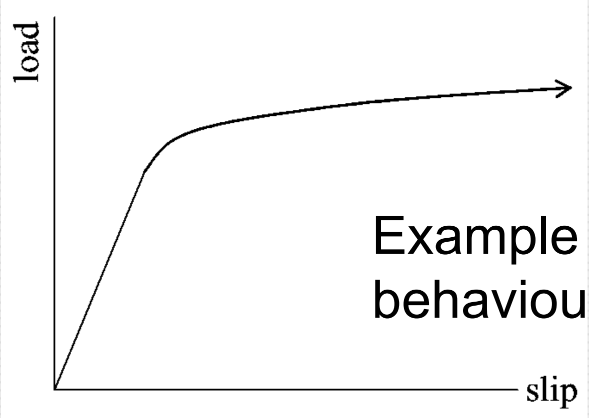
Ductility in connections:

Ductility is specified with a non-linear stress/strain behaviour.



Example for ductile behaviour

- Non-linearity and handling of large pools of various load cases can only be carried out with enormous additional effort.
- The non-linearity can be neglected in structural calculations, in order to be able to perform linear superpositions for all load cases.
- When neglecting non-linearity how to check, whether ductility helps or helps not (see following example)

Ductility in connections:

Question: for what do we need ductility
Is ductility **ALWAYS** a benefit for structural systems?

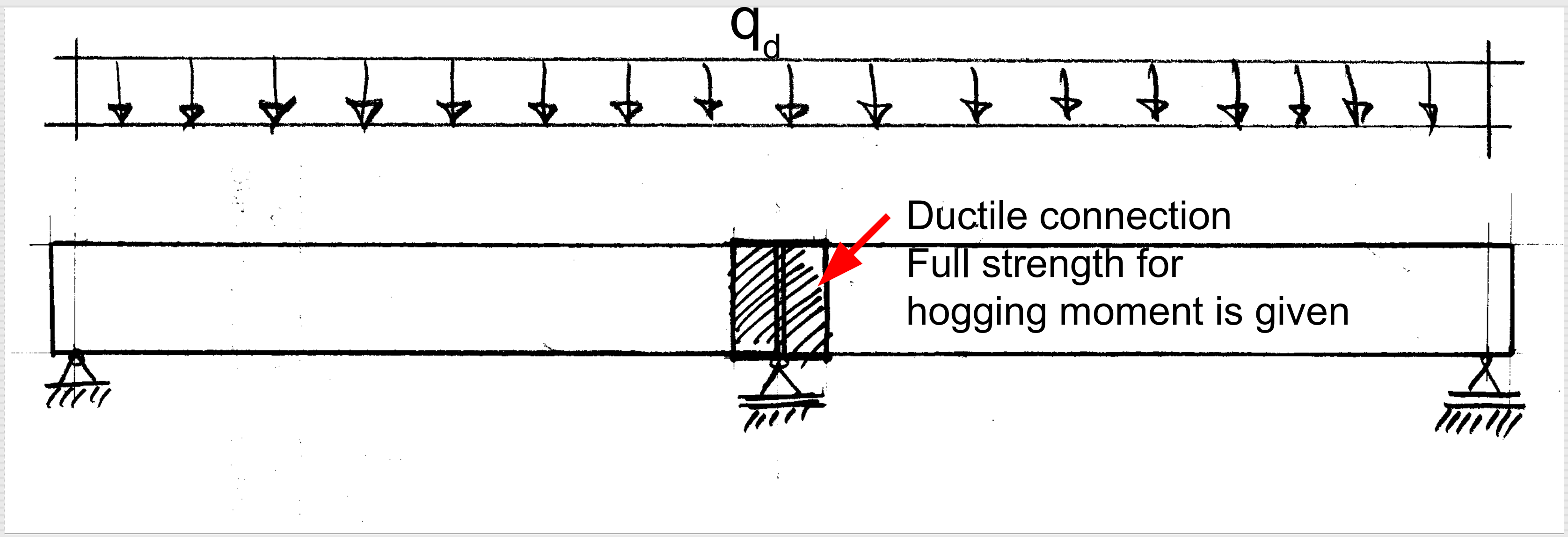
Ductility is needed for
(a) increase of ultimate load carrying capacity of a structure
(b) better behaviour of a structure in load situations like earth quake

- Ductility is definitely important for case (b), because earth quake lives from energy dissipation, which can be done in ductile connections.
- Questions remains, wheather ductility in form of ductile connections lead always to higher ultimate load carrying capacity (a).
- The following example will show, that this is **not always** the case.

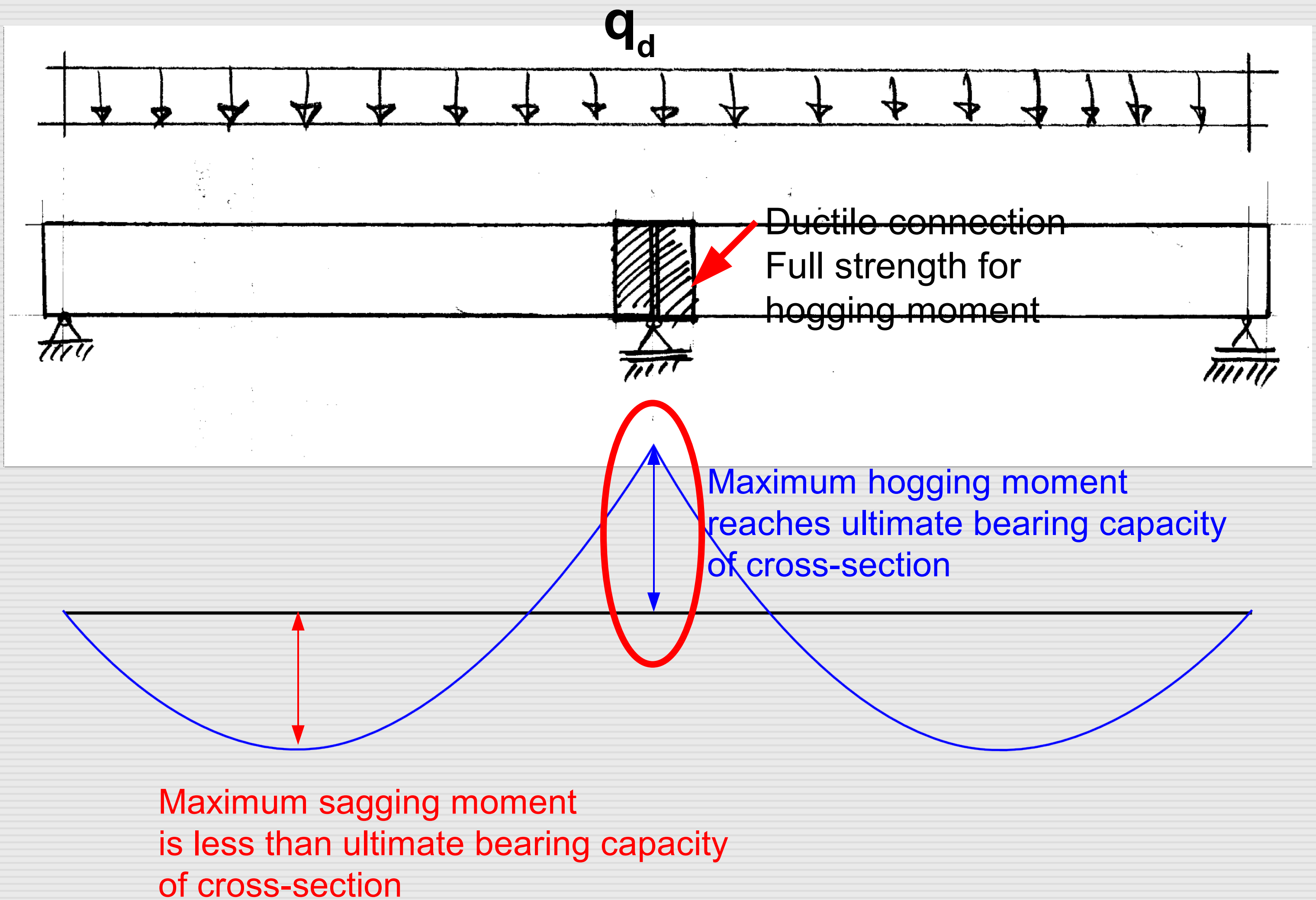
Example 1: ductility is **positive** for load carrying capacity

System is a continuous beam, build up by two beams, which are connected in the middle by a full strength, ductile connection system.

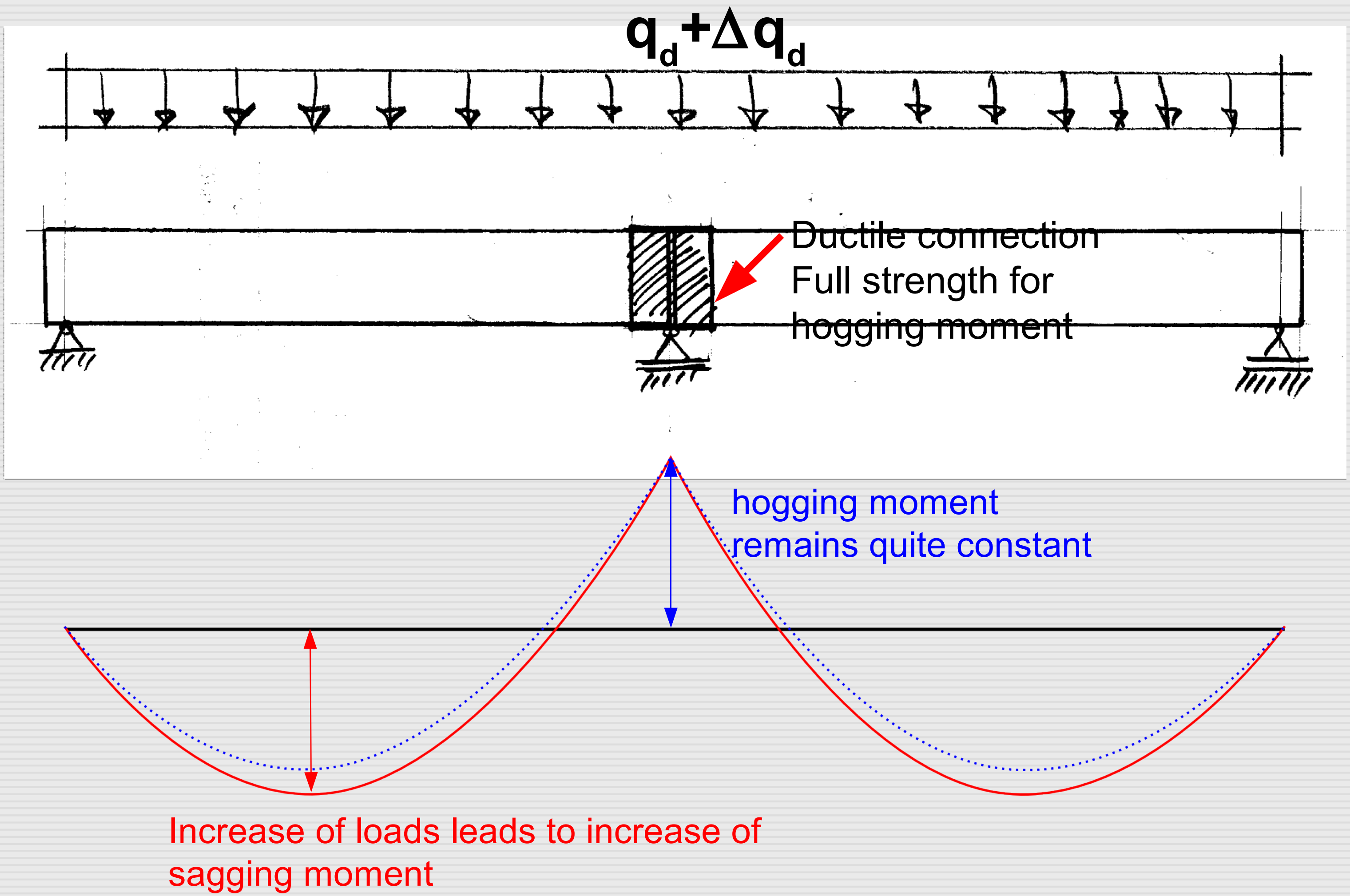
Uniformly distributed load with magnitude q_d load is acting on the system.



Example 1: moment distribution under load q_d



Example 1: moment distribution under load $q_d+\Delta q_d$



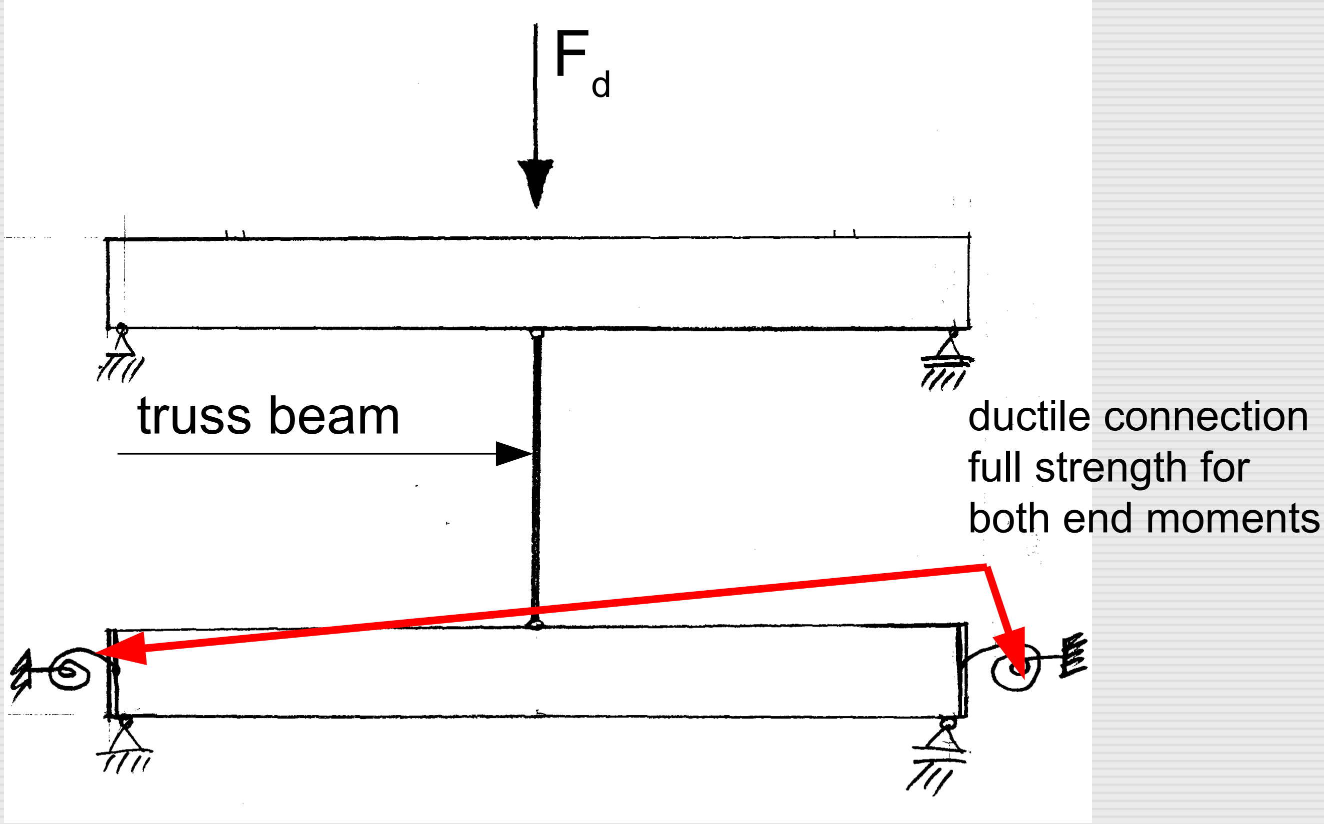
Example 1: conclusions

- System can redistribute internal stresses due to ductility of connection
- Some additional loads can be carried by the structure
- Similar behaviour as if it is a construction made of steel

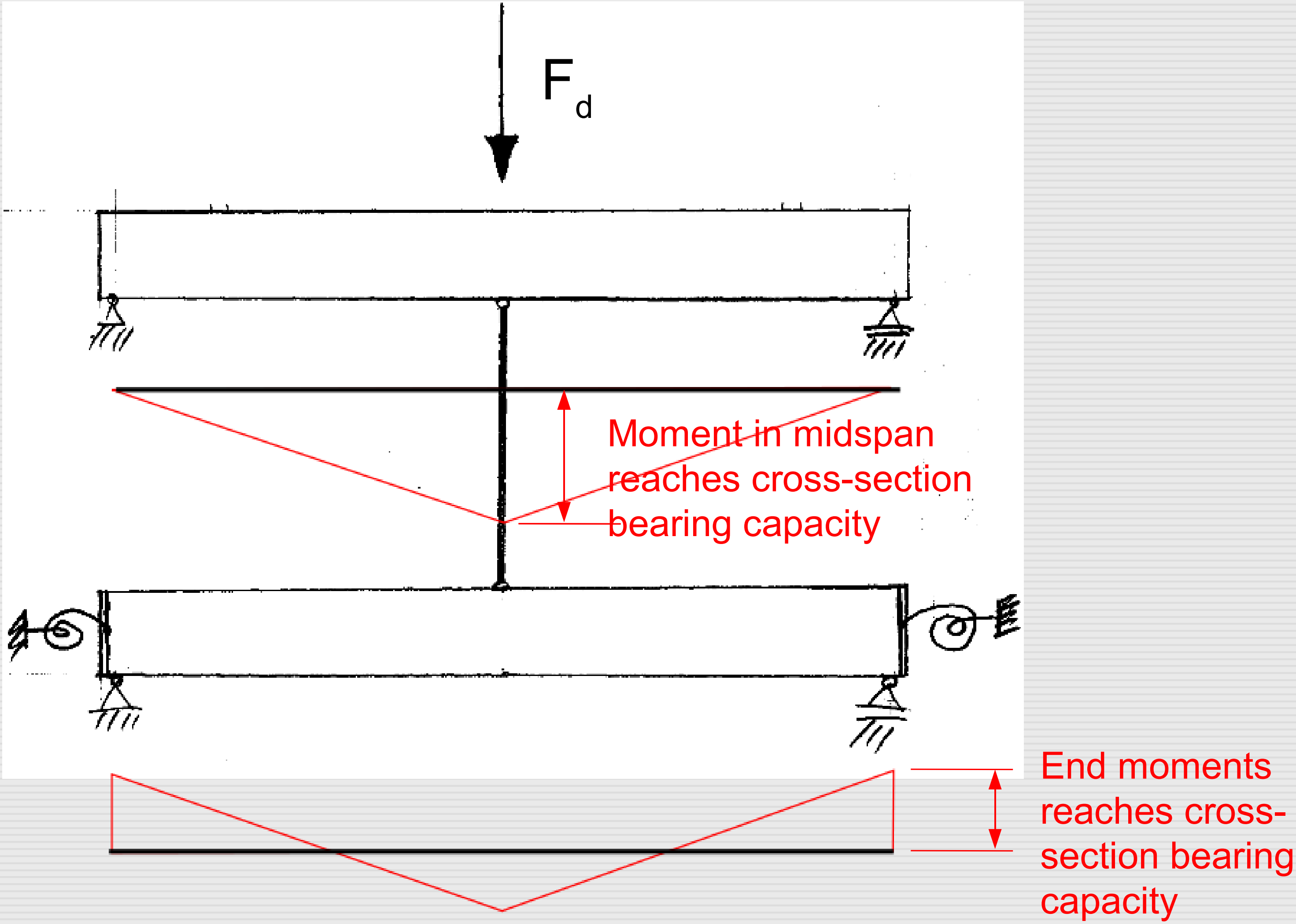
- DUCTILITY of connection helps for more robust structure!

Example 2: ductility is **not positive** for load carrying capacity

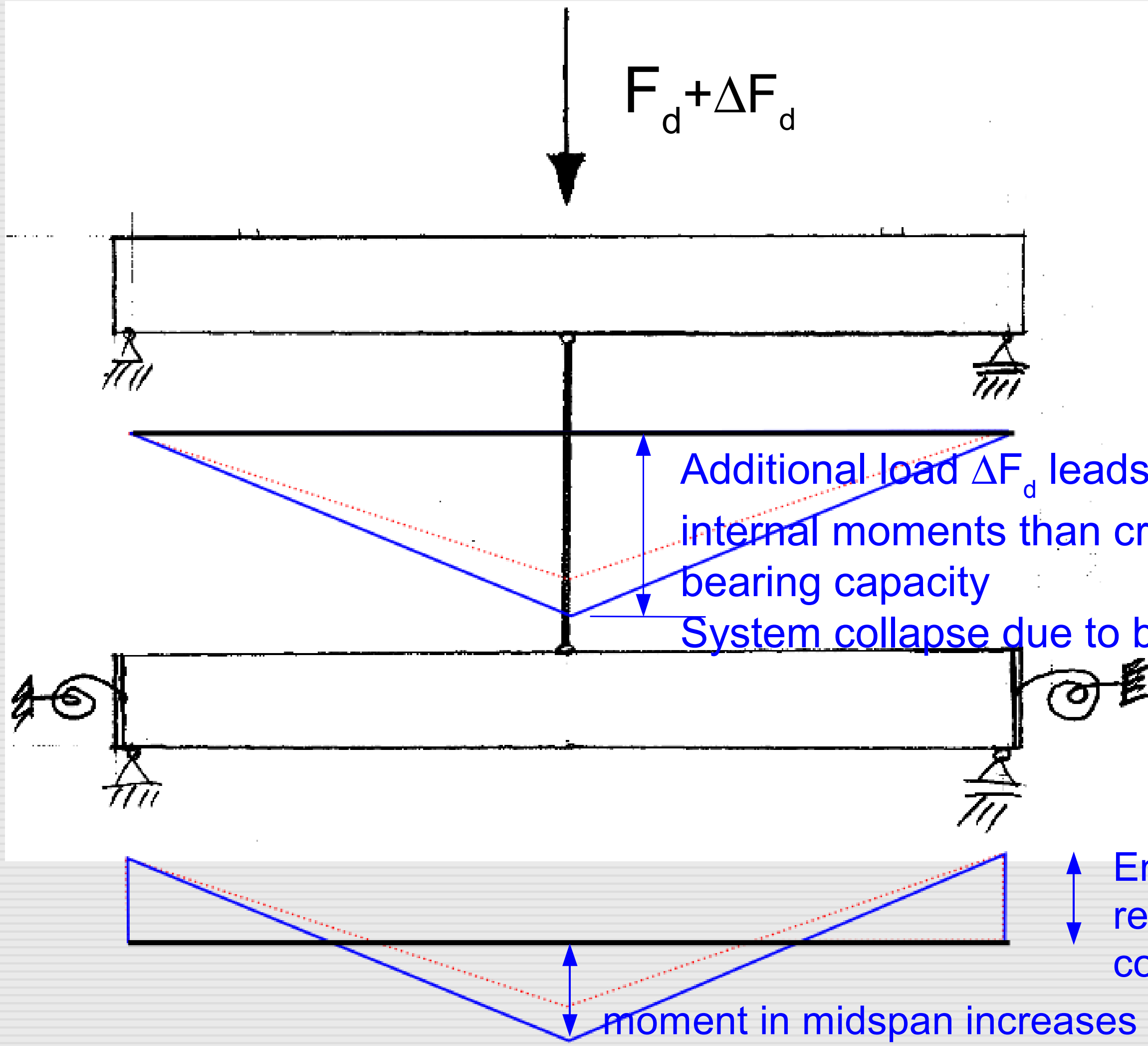
System consists of two beams, which are connected by a rigid truss member in midspan. While above beam is simple supported, lower beam is fixed against rotation at both support points with a ductile moment connection



Example 2: moment distribution under load F_d



Example 2: moment distribution under load $F_d+\Delta F_d$



Example 2: conclusions

- System of example 2 can NOT redistribute internal stresses. Brittle behaviour leads to collaps before ductility of connections can be taken into account.
- No additional loads can be carried by the structure. Different behaviour to a construction made of steel can be observed!

General conclusions

- A simple verification is only secure for structures (steel constructions), where **ALL** parts (members, connections) behave ductile.
- In constructions, where some parts like timber beams behave brittle, a detailed investigation has to be carried out, in order to verify, that an early collapse of a non ductile member does not result in a total collapse of the entire system.
- This last fact includes, that for timber construction a complete non linear study for all possible load combination has to be carried out. This is a very challenging job.