Robustness versus Human Errors

COST E55
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The causes for failures can be divided into four types:
1. errors in the design
2. errors during construction
3. lack of maintenance
4. unforeseeable incidents

The first two types are often called human errors or gross errors and accounts for far the major parts of failures according to eg. Frühwald et al. (2007). They include incompetence of the designer and the contractor and therefore also those unforeseen conditions, which were not unforeseeable for the qualified designer or contractor.

A failure caused by degradation might have been unforeseeable for the designer but sufficient inspection and maintenance would prevent most failures du to degradation. It is therefore just another sort of human error, and is also frequent.

There is very little left as truly unforeseeable incidents. It could be an earthquake in an area where this were not regarded a risk, or a terror action. It could also be a component with a random weakness causing a very low strength.

The nature of the first two types are that the errors are usually repeated throughout the structure, meaning that all similar components are similarly weak.

An attempt to ensure robustness by means of a parallel system that enables redistribution of the loads in case of failure of one component might therefore cause collapse of the entire structure because the other components also are weak. A deliberate weak link might limit the failure, but part of the structure will most likely collapse.

Degradation might also affect the entire structure, eg. because of delamination, and therefore repeated throughout the structure with consequences as above.

But degradation can also be restricted to a single spot, eg. due to a leaking roof.. It is likely that failure occurs at a time with high - but not extreme - load. Then redistribution of the load becomes attractive because it is most likely that the neighbor components are able to sustain the extra load.

An unforeseeable incident might also be located at a small area. In these cases the ability to redistribute load might limit the consequences. If the unforeseeable incident covers the whole structure is difficult to judge weather ability to redistribute load is an advantage or not.

Discussion

In principle robustness is aimed at reducing the risk of human injuries in the case of an unforeseable incident. It is assumed that the structure fulfils the requirements of the codes. Under these assumptions parallel systems are very attractive as they will minimize the consequences and perhaps prevents collapse.

Some guidelines mention overdesign of key elements in series systems as a substitute for parallel systems, but this is against the idea of robustness to try to design for an unforeseable incident.

But in real life most failures are related to human errors such that the structure does not fulfill the code requirements. Limiting the consequences of a failure in case of a systematic human error demands that load is not significantly redistributed. Weak spots appear to be the only way to ensure that. But the failure will cause part of the structure to collapse.

Therefore, when advising strategies for ensuring robustness it must be considered if the strategy might increase the consequences of human errors.