

## THE IMPORTANCE OF ESTIMATING DAMAGE POTENTIAL

In any geotechnical investigation for a proposed structure or an existing structure where there is the threat of damaging ground movement, the most important assessment is the predicted damage potential. The predicted damage level will drive the project in terms of foundation type, ground treatment, and even abandoning a site for development, due to either the risk reduction or remediation costs. Therefore, a trusted risk analysis and a cost-effective mitigation plan which suits the owner's needs is a vital service the selected consultant should provide.

### DAMAGE TYPE

The damage potential is composed of three elements. They are damage type, severity, and likelihood (risk). Furthermore, the damage to a structure can be classified into four categories: functional, aesthetic, structural, and/or environmental.

**Aesthetic** (aka cosmetic or architectural) damage concerns damage to non-structural elements, the severity of which is subjective (i.e. 'in the eye of the beholder'). Examples of aesthetic damage would be cracking in the masonry veneer, drywall, and concrete floors, and the tilt or slope of the floor. Examples of aesthetic damage are shown in Figure 1. Consequently, the level of repair required for such damage is also subjective.



FIGURE 1 EXAMPLES OF AESTHETIC DAMAGE



Drain installed to bleed tilted overhead water pipe

Door frame adjusted to properly close the door

Undraining storm system

FIGURE 2 EXAMPLES OF FUNCTIONAL DAMAGE

**Functional** damage refers to damage to elements which, to some degree, impairs their intended function. This would include sticking to completely stuck doors or windows, adversely tilted gravity fed plumbing, broken pipes, etc. Some examples are depicted in Figure 2.

**Structural** damage is damage that has significantly weakened or yielded load bearing superstructure or foundation elements. These elements may provide support against, for example, the vertical weight of the building, lateral wind forces, earthquake motions, or from earth movements. Structural damage is when the capacity of the load supporting elements has been reduced to an unacceptable level. Foundations or superstructure elements can be structurally damaged by crushing, cracking, shifting, tilting, buckling, and/or bending. Included within structural damage would be damage to the ground which supports the structure, subsidence, landsliding, and earthquake motions which can all cause the ground and structure to weaken. Some examples of structural damage are shown in Figure 3.

**Environmental** damage from ground movement is related to spillage of hazardous material into the subsurface and groundwater. It is also typically related to breaks in petro lines. See Figure 4.

## DAMAGE SEVERITY

In understanding the damage potential, it is also important to determine the possible damage severity in addition to the type of damage risk. The elements of damage severity include hazardous level, intensity, extensiveness, and rate of the damage. For example, there are certain events which cause intense patterns of deformations with little warning; such as from abrupt mine subsidence, whereas others occur gradually and may reach the same level of damage but over a very long period of time, such as from a cover subsidence from karst. Slow moving deformation can make a difference in preventing hazardous conditions and ability to tolerate the risk.

## DAMAGE PROBABILITY (RISK)

The last component of the damage potential is the likelihood of a certain type of damage event from occurring. This is commonly quantified with terms of remote, very low, low, moderate, and high chance.

## RISK MANAGEMENT

The type and extent of remediation which is taken, if any, in essence depends on the risk of damage potential the owner is willing to assume. Given the same damage potential, depending upon their previous experience, public safety tolerances, and economic and other administrative policy determine the overall allowable risk, and consequently the necessary remediation. Here, public safety issues involve the risk of hazardous or unsafe conditions. This can be present in all of the above types of damages from aesthetic to environmental, each of which has its own risk level. For example, this can be in the form of a tripping hazard, shard window glass, or a potential structural collapse. Another aspect of this might be public perception. This would be the perception of the public of the safety of a facility that has sustained damage despite the fact that the building may be completely safe.



FIGURE 3 EXAMPLES OF STRUCTURAL DAMAGE



FIGURE 4 EXAMPLE OF ENVIRONMENTAL DAMAGE

## SUMMARY

As an owner/owner representative you should always get an adequate understanding of the potential damage from an informed professional, including the type of damage expected. For example, as severe structural damage is clearly different from severe aesthetic damage. A question the owner/owner representative should ask is: What does the noted intensity or the risk level mean? Definitions of such nomenclature should not be assumed as they drive risk management decisions. It is our experience that there can be a significant and critical difference in these unspoken/unknown/assumed definitions upon which property decisions are unfortunately made.

### Other Engineering UPDATES that may be of Interest:

[UPDATE # 5: Response of House Foundations During the Loma Prieta Earthquake](#)

[UPDATE #8: Geotechnical Investigation of Building Damage](#)

[UPDATE #11: Frozen Fill Causes Building Damage](#)

[UPDATE #32: Developer Avoids Substantial Risk of Subsidence Damage](#)

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**FOR MORE INFORMATION:** There is a significant amount of additional information that is available on the above subject. For more information, please contact Dr. Marino at the address listed below.