BASICS OF LONG-TERM DEFLECTIONS[1]

This narrative explains the essentials of long-term deflection of concrete members. For details refer to TN292.

- Long-term deflections are due to (i) shrinkage and (ii) creep.

SHIRINKAGE

- Shrinkage starts as soon as concrete is exposed to the environment and loses moisture through its surface. Figure 1 shows the typical change of deflection due to shrinkage with time.
  - Shrinkage does neither depend on the time of loading, nor the magnitude of the applied loads
  - Shrinkage deflection (normal to member) depends on the amount and position of reinforcement. The larger is the difference between top and bottom reinforcement, the more will be shrinkage deflection.
  - Due to the positioning of reinforcement, in most structures shrinkage deflection is affine to deflection under selfweight.

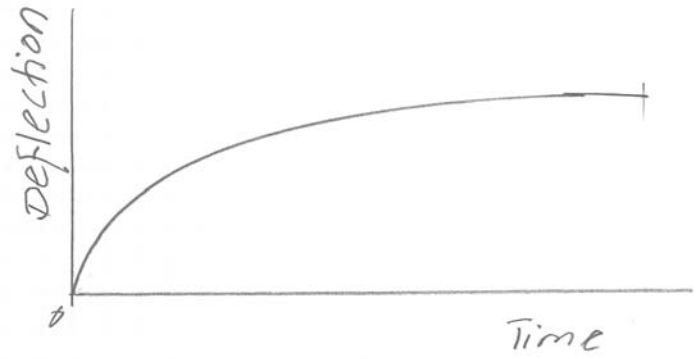

FIGURE 1 SHRINKAGE DEFLECTION WITH TIME

CREEP

- Creep deflection is initiated when a member is subject to load. Refer to Fig. 2. When load is applied on day "T," there is an instantaneous elastic deflection (d). With time, the deflection under load increases - initially at a higher rate. The creep deflection is generally around 2 times the instantaneous deflection. The instantaneous deflection is generally calculated assuming concrete is 28 days old, using the modulus of elasticity for day 28. When loaded at a later date, the modulus of elasticity is more, leading to a lesser creep deflection.

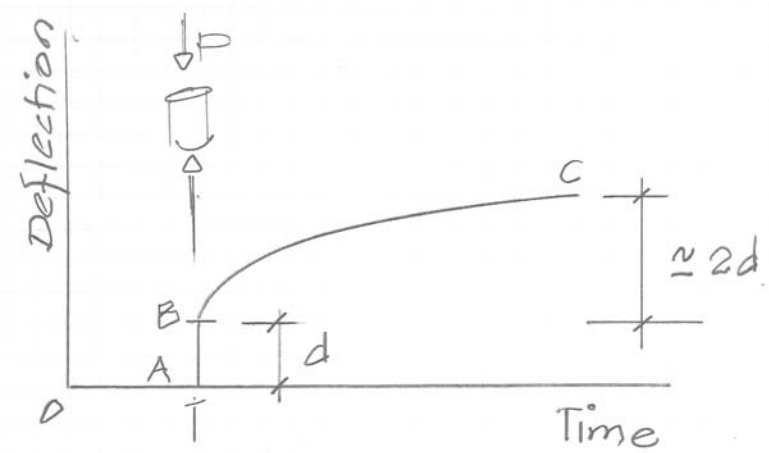

FIGURE 2 CREEP DEFLECTION WITH TIME

- Refer to Fig. 3. When loaded on day 5, a member deflects d1 and continues to deflect due to creep. When a second load is added on day 15, there will be a lesser instantaneous deflection (d2) due to aging (increase in modulus of elasticity). Past day 15, the member continues to creep due to both loads.

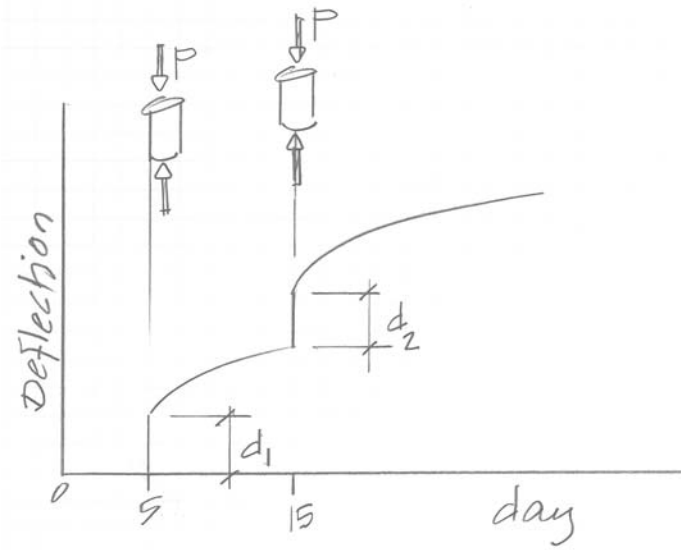

FIGURE 3 CREEP OF MEMBER WITH MULTIPLE LOADS

LONG-TERM DEFLECTIONS

Two items are central in estimating the long-term deflection of a member for compliance with serviceability.

- First is the purpose.
  - If the objective is to control damage to non-structural elements attached to a member, the deflection “subsequent” to installation of the items that are likely to be damaged would apply. In this case one needs to estimate the day when such elements are installed and calculate the deflection subsequent to that date.
  - If the purpose is visual perception of deflection, the perceived value will be the total displacement, irrespective of the time of application of the loads minus camber. In many instances this applies to perception of deflection for exposed soffits. Where stone or tiles

are used, prior deflections are disguised by the layer of mortar that is used to set the floor cover.

- ACI-318 as well as other codes have recommended curves or formulas to estimate long-term deflections. For example, referring to the ACI curve (Fig. 4), if a member is loaded after 3 months, the balance of deflection due to "prior" loads is only 1 times the instantaneous displacement experienced when prior loads were applied. A similar curve extracted from PCI manuals is given in Fig. 5. For detailed examples and more explanation refer to TN 292

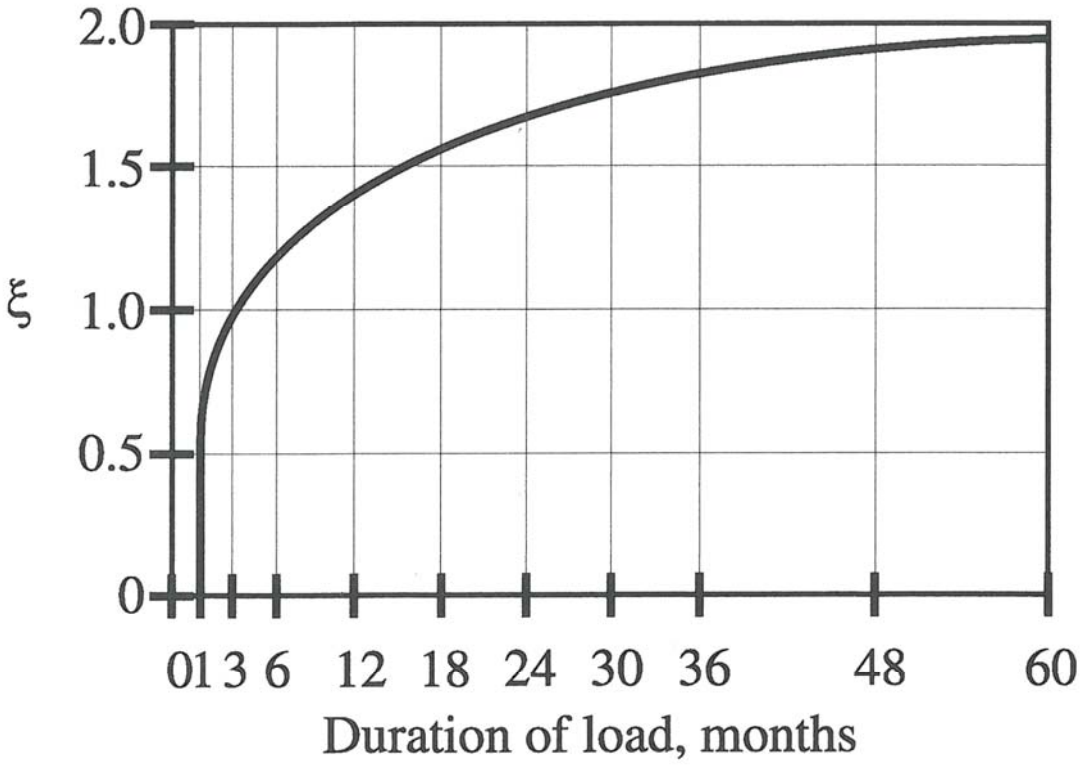

Fig. R9.5.2.5—Multipliers for long-term deflections

Fig. 4

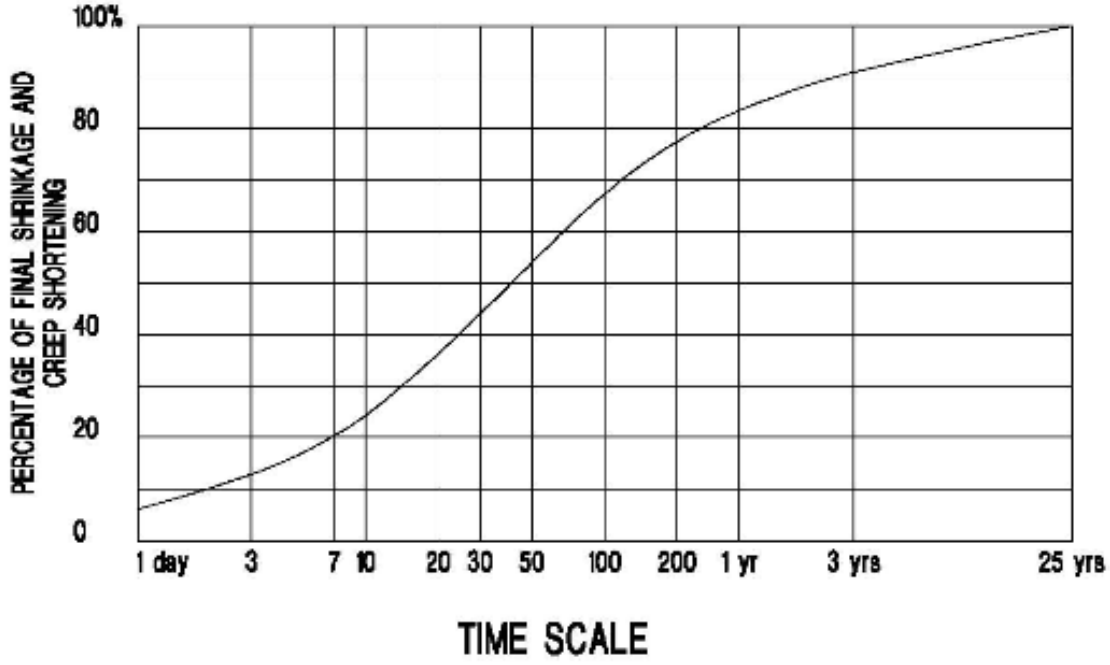

FIGURE 5 LONG-TERM SHORTENING OF CONCRETE MEMBERS DUE TO CREEP AND SHRINKAGE WITH TIME