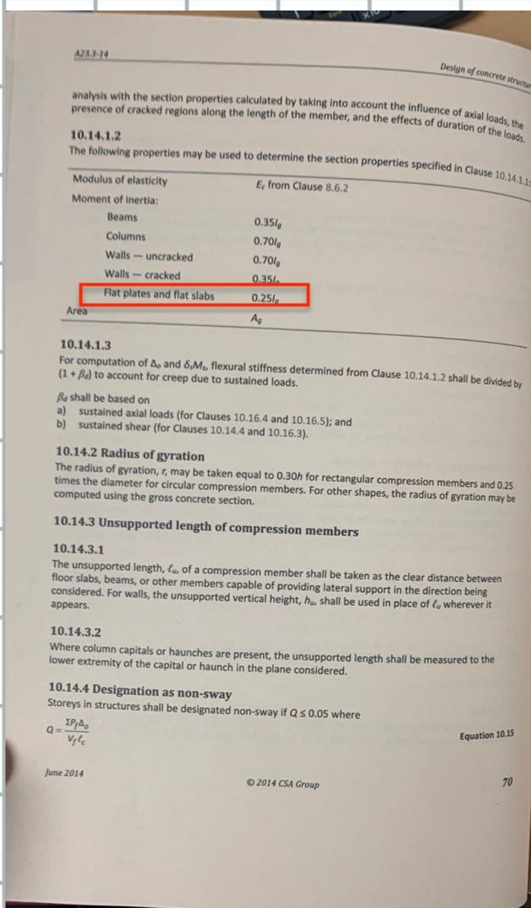
OMAR SHEMY PORTFOLIO

SUBJECT: **Typical slab study of cantilevers for strength and deflections**

DATE	PROJECT NO.	PROJECT NAME	ENGINEER	PAGE
2024 JAN 17	**202401**	**DEMO PORTFOLIO**	**O.S.**	**1**

1. **Linear Analysis 9.5" slab, 35 MPa compressive strength, moment of Inertia modified to 25%**



A23.3-14 — Design of concrete structures

analysis with the section properties calculated by taking into account the influence of axial loads, the presence of cracked regions along the length of the member, and the effects of duration of the loads.

10.14.1.2

The following properties may be used to determine the section properties specified in Clause 10.14.1.1:

Modulus of elasticity	E_c from Clause 8.6.2
Moment of inertia:	
Beams	$0.35I_g$
Columns	$0.70I_g$
Walls — uncracked	$0.70I_g$
Walls — cracked	$0.35I_g$
Flat plates and flat slabs	$0.25I_g$
Area	A_g

10.14.1.3

For computation of Δ_o and $\delta_s M_s$, flexural stiffness determined from Clause 10.14.1.2 shall be divided by $(1 + \beta_d)$ to account for creep due to sustained loads.

β_d shall be based on

a) sustained axial loads (for Clauses 10.16.4 and 10.16.5); and

b) sustained shear (for Clauses 10.14.4 and 10.16.3).

10.14.2 Radius of gyration

The radius of gyration, r, may be taken equal to $0.30h$ for rectangular compression members and 0.25 times the diameter for circular compression members. For other shapes, the radius of gyration may be computed using the gross concrete section.

10.14.3 Unsupported length of compression members

10.14.3.1

The unsupported length, ℓ_u, of a compression member shall be taken as the clear distance between floor slabs, beams, or other members capable of providing lateral support in the direction being considered. For walls, the unsupported vertical height, h_u, shall be used in place of ℓ_u wherever it appears.

10.14.3.2

Where column capitals or haunches are present, the unsupported length shall be measured to the lower extremity of the capital or haunch in the plane considered.

10.14.4 Designation as non-sway

Storeys in structures shall be designated non-sway if $Q \leq 0.05$ where

$$Q = \frac{\Sigma P_f \Delta_o}{V_f \ell_c} \quad \text{Equation 10.15}$$

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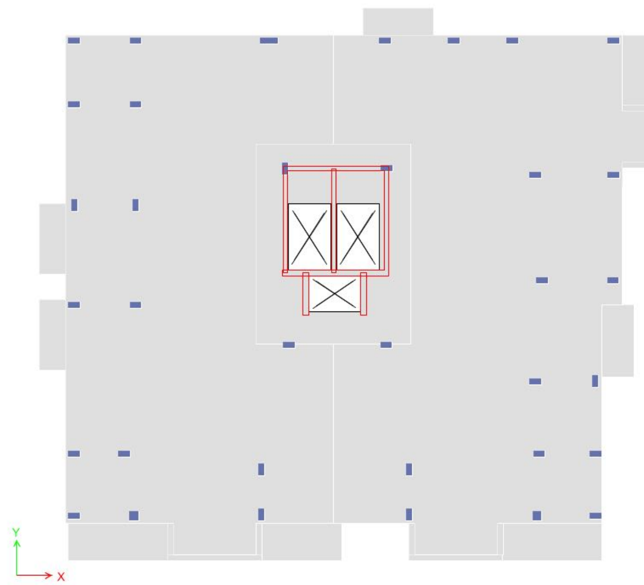
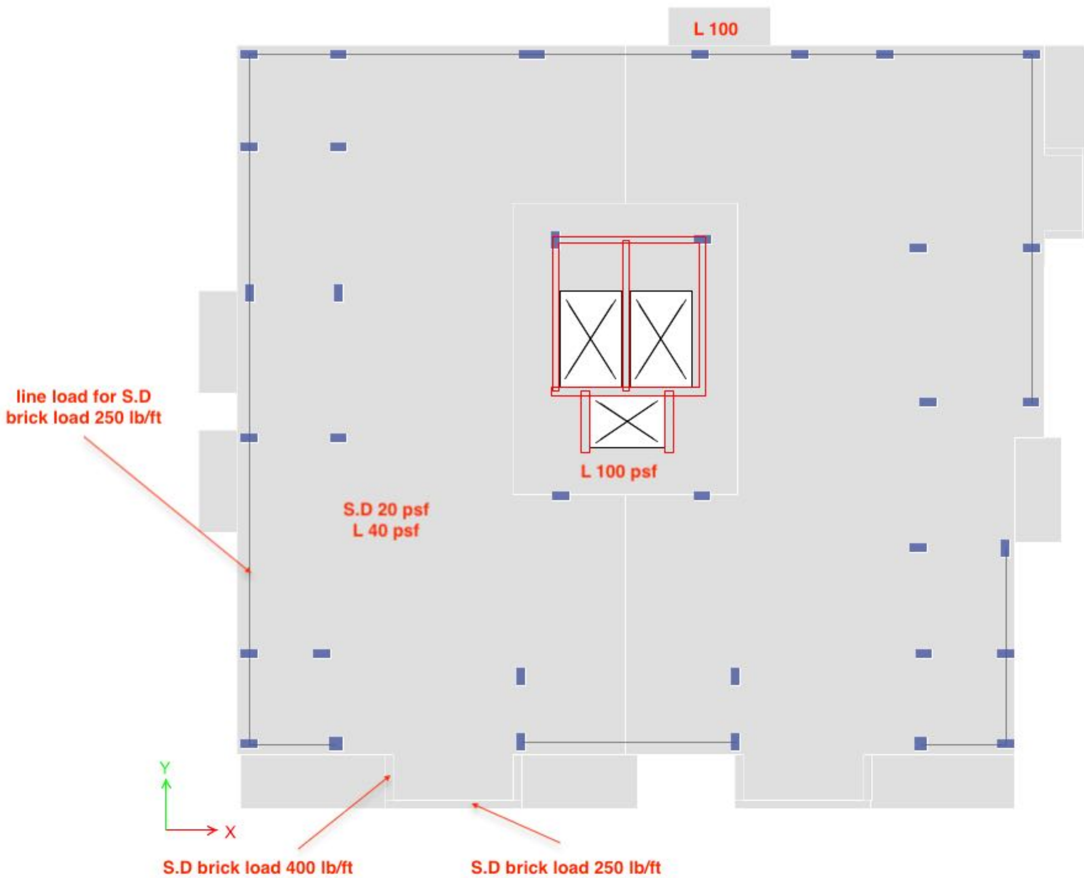
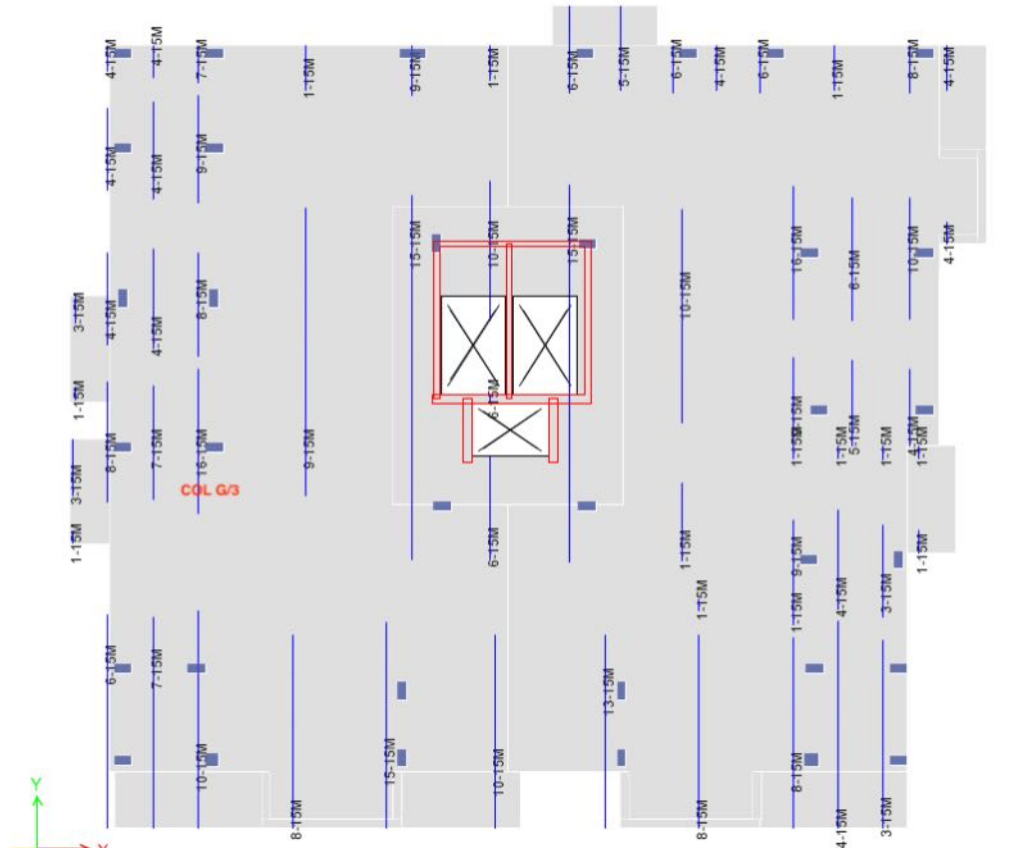


2. Loading assumed



3. Strength results



Analysis summary:

a) **ETABS top steel design, in the outermost layer, sample of the output that would be compared to the spSlab output on the next page.**

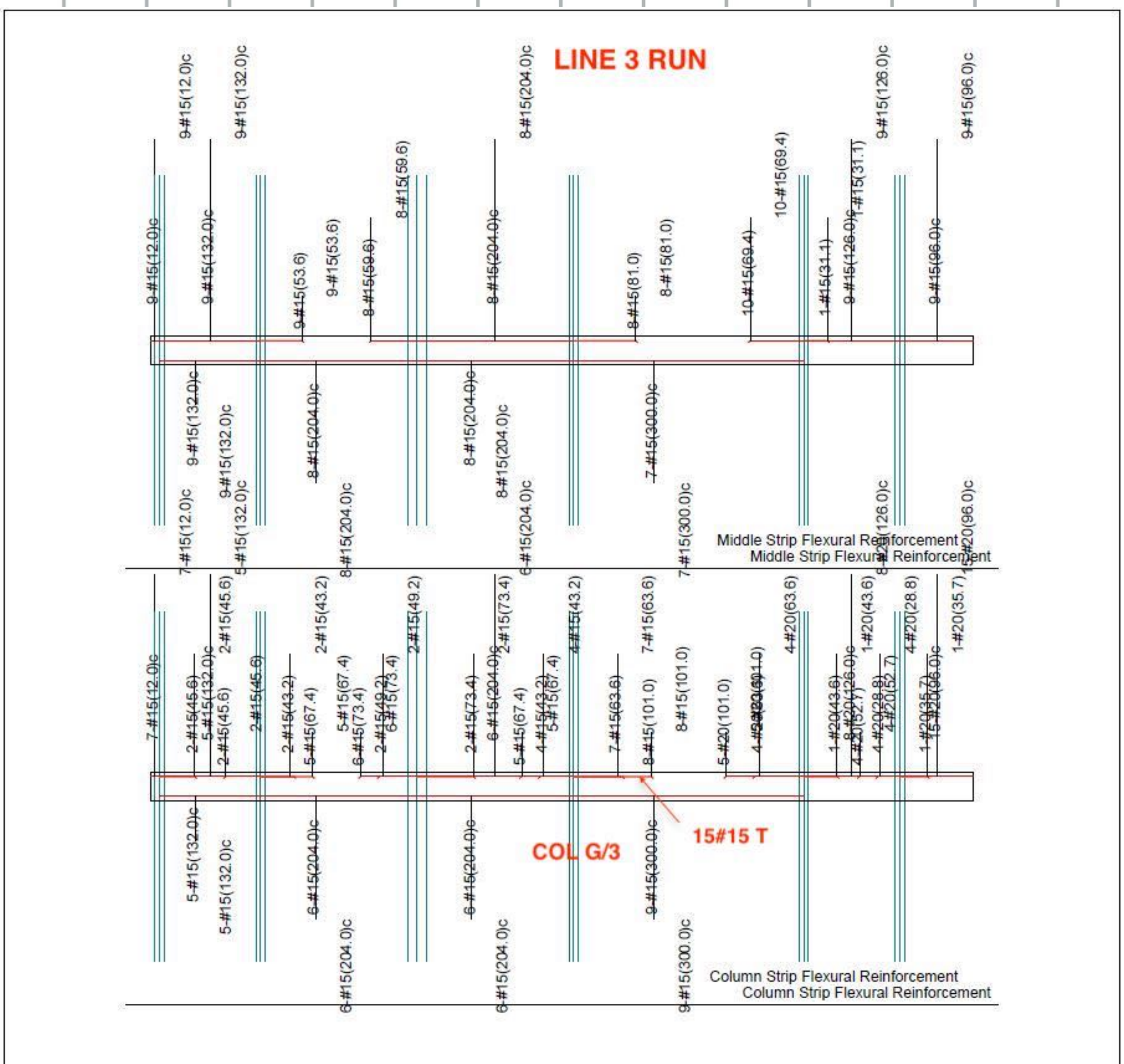
b) **I labelled col G/3 to make a quick comparison across one line (line 3).**

c) **Middle strips pass through walls and openings, to simplify the strips drawings procedure and save some time during drawing, the rebar output in those areas, to be overlooked for simplicity.**

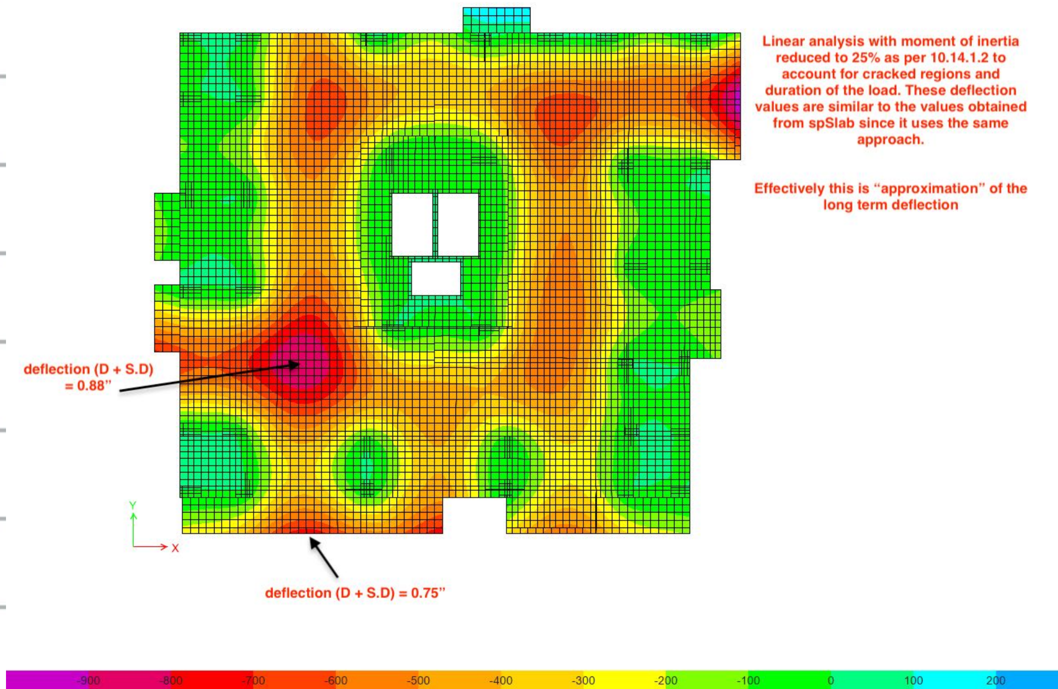
d) **Additional top bars at the walls and near the edge of the slab, will be added as required to compliment this output.**

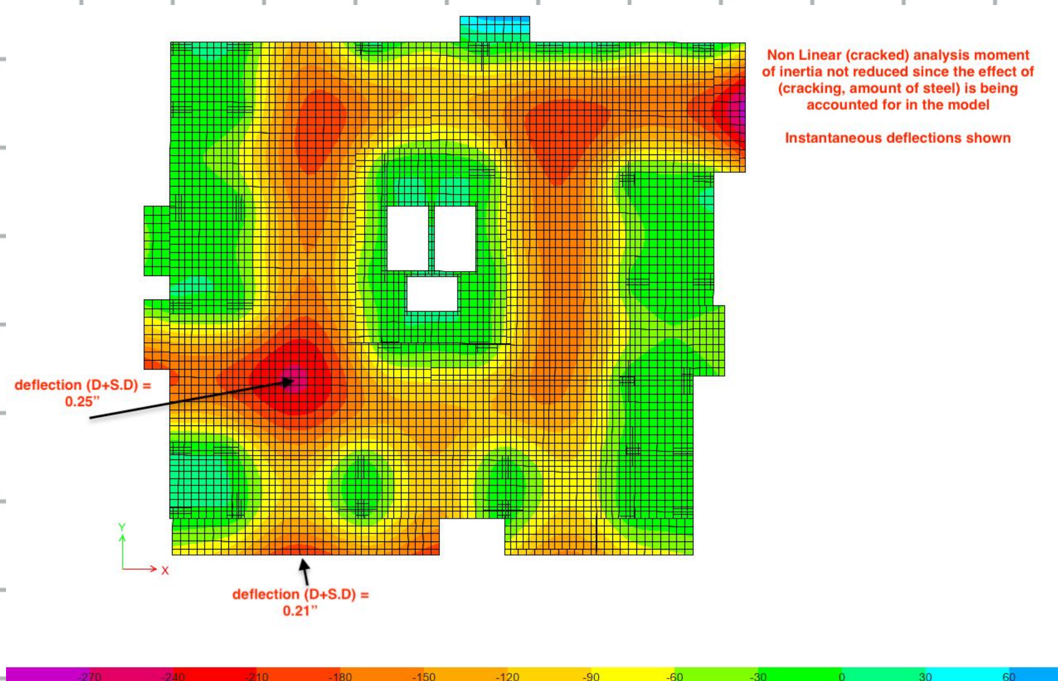
e) **Similarly bottom bars for integrity steel, at the walls, corners and areas where cracking is susceptible, will be added as required to compliment this output.**

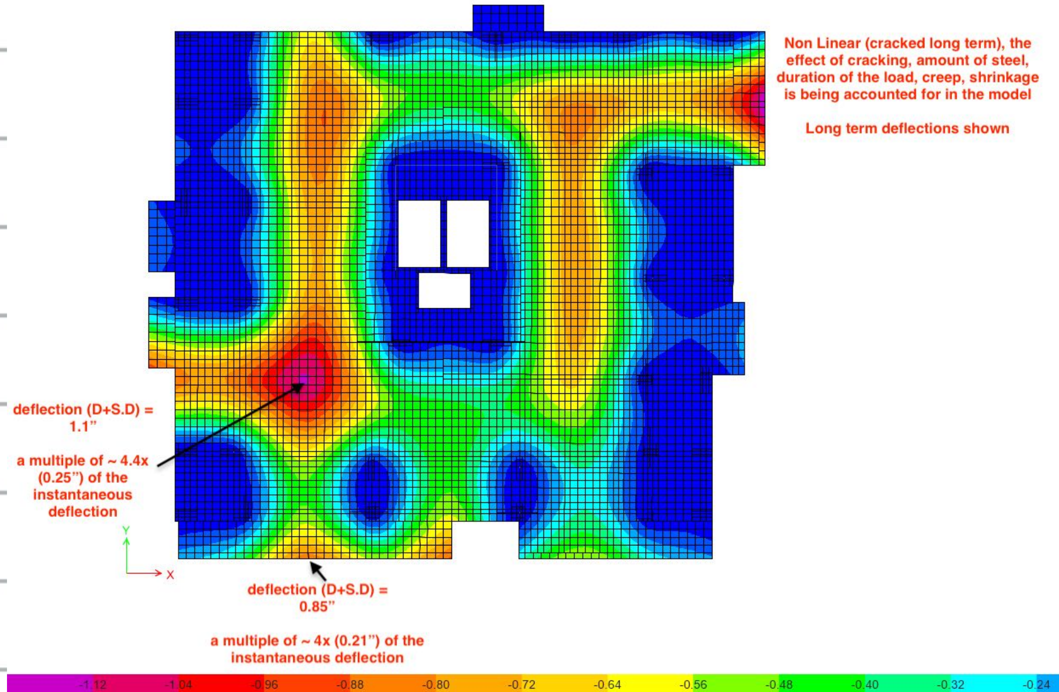
4. spSlab results



5. Deflections







Analysis	Linear analysis			Nonlinear analysis (cracked) long term		
Deflection (inch)	Instantaneous	Long term	ratio	Instantaneous	Long term	ratio
Cantilever tip	0.25	0.75	3.00	0.21	0.85	4.00
Between G/3 and J/3	0.29	0.88	3.00	0.25	1.10	4.40

a) Using linear analysis, the long-term deflections are always a multiple of 3.0 of the short-term instantaneous deflections in (spSlab or ETABS linear analysis)

b) The factor of 3 comes from the formula shown on the next page clause 9.8.2.5; using (compression steel ratio) $\rho' = 0$ and (long term deflection factor for sustained loads, Table 6.6) $S_t = 2.0$

c) To account for compression steel using the manual method, add #15 bars in the area of interest at 8" (compression steel ratio A/bd = 0.004), gives a long-term factor of 2.7

d) Deflection at cantilever tip would be 0.25*2.7" = 0.68"

e) Nonlinear analysis accounts for cracking of concrete, iterative nature of solution (level of reinforcing steel) and duration of the load (creep and shrinkage)

f) The ratio between long term and instantaneous deflections varies depending on the span, geometry, loading condition and level of reinforcing steel

6.4 Long-Term Deflection Computations

Instantaneous deflections of concrete flexural elements are increased due to additional long-term deflections caused by shrinkage and by creep due to sustained applied loads. Figure 6.5 shows the deflection time history of a typical concrete element:

- the instantaneous deflection due to the self weight of the member, $\Delta_{i,SW}$, that occurs when the forms are "flown" when the concrete is assumed to be one week old.
- the increase of the self-weight deflection due to shrinkage and creep, until the superimposed dead load is applied when the concrete is assumed to be three months old.
- the instantaneous deflection due to the superimposed dead load, $\Delta_{i,SDL}$.
- the additional deflections due to shrinkage and creep under the sustained self-weight and superimposed dead loads.
- the instantaneous deflection due to the sustained live load, $\Delta_{i,SLL}$, assumed applied when the concrete is nine months old. The sustained live load is often assumed to be 20 to 25% of the total live load for residential or office buildings: this fraction can be much higher for storage facilities including warehouses and libraries.
- the additional deflections due to shrinkage and creep under the sustained self-weight, superimposed dead and sustained live loads.
- the instantaneous deflection due to the instantaneous live load $\Delta_{i,ILL}$.

Table 9.3 of A23.3-14 often requires that the deflection to be considered must be "that part of the total deflection occurring after the attachment of non-structural elements likely to be damaged by large deflections". As is clear from Fig. 6.5, this can be in the order of half of the total deflection and is primarily due to the long-term deflection caused by the sustained self-weight, superimposed dead, and live loads.

Both the total deflection and the deflection occurring after the attachment of non-structural elements are sensitive to the loading history of the member. If the instantaneous portion of the live load is applied at the end of the service life of the member, the initial deflections due to sustained applied loads and the long-term increases of these deflections loads will be relatively small. If the instantaneous portion of the live load is applied at the beginning of the service life of the member, or if construction loadings subject the member to large moments, then the initial deflections and associated long-term deflection increases due to sustained loads will be much greater. Unless the loading history can be accurately forecast, it is prudent to assume that the construction loadings will cause applied moments that equal approximately those due to the specified dead and live loads.

Clause 9.8.2.5 of A23.3-14 allows the total deflection to be computed as

$$\Delta_t = \left[1 + \frac{S_t}{1+50\rho'}\right]\Delta_i$$

where Δ_t is the total (i.e., instantaneous plus long-term) deflection, S_t is the factor for creep deflections due to loads sustained for a duration t, ρ' is the compression steel reinforcement ratio, A_s'/bd, and Δ_i is the instantaneous deflection. If steel at the compression face has insufficient development length for compression reinforcement it does not qualify as compression steel for this calculation.

Fig. 6.6 shows the variation of S_t with load duration and Table 6.6 gives equations to compute S_t, for loading durations between 1 week (i.e., 0.25 months) and 5 years (i.e., 60 months).

6

Deflections

Table 6.6

Equations for S_t: long-term deflection factor under sustained loads

Range of load duration, t (months)	Equation for S_t (note: t in months)
0.25 to 12	$S_t = 0.683 + 0.289\ ln\ (t)$
12 to 60	$S_t = 0.474 + 0.373\ ln\ (t)$
greater than 60	$S_t = S_\infty = 2.0$

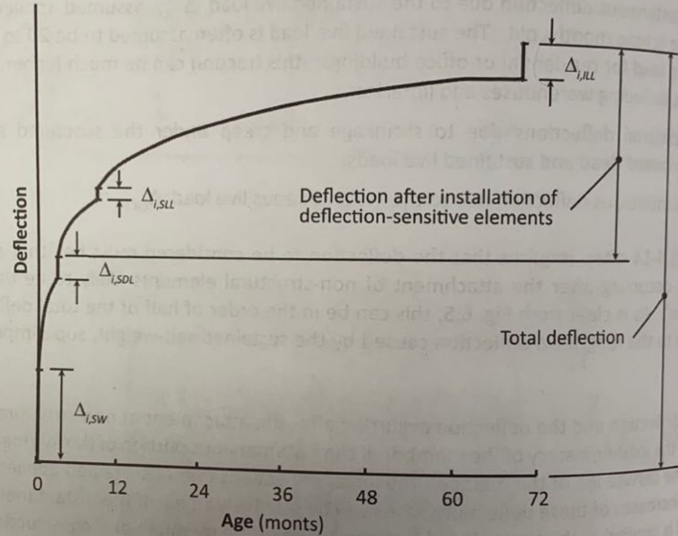


Fig. 6.5 Time history of flexural deflections for a typical concrete beam or slab