C1. Detailed Design - Introduction

With the conceptual and preliminary design complete this section now looks at the detailed design requirements. This starts by detailed determination of loads including self weight, construction live load, in service live load and wind load. While this part may be very “elementary” there are some important issues that need to be appreciated concerning the characteristics of construction live loads and the application of various live load reduction factors. Using the detailed loading information, the various structural members are then checked against code requirements with the primary focus being on the detailed design of the erection columns, the composite beams, composite slab and connections. Consideration is also given to design of the shear core.

To understand the design of composite beams it is critical to appreciate that these beams must be designed for (at least) three fundamentally different configurations during their “life cycle” as discussed in section B4. AS2327.1 actually defines 7 different stages at which the beams should be checked but generally only three of these are critical as illustrated on the following page. At Stage 1, the beams are lightly loaded but unrestrained against beam buckling. At Stage 3, the beams carry the weight of the freshly poured concrete without the advantage of composite action. Only in the final Stage 7 when the building is complete, do the beams act compositely with the slab to support the in service loads.

Composite slabs must also generally be designed for three different stages or configurations. At the “wet concrete” stage, the decking must span between its supports (just like roof sheeting) to support the weight of the fresh concrete and the construction live load. (This is the stage that sets the maximum slab span as previously determined.) Once the concrete has gained strength then in the second “service” stage, the decking and concrete will act compositely to resist the service live loads. At this stage the decking effectively represents external bottom reinforcement to the slab. The third stage relates to performance of the slab during a fire event when the decking heats up and loses strength effectively leading to a situation where there is potentially no bottom reinforcement in the slab.

For both the beams and the slab, any one of the three potentially critical stages, may be the governing stage for the design.

C2. Design Stages and Construction Loading

- Refer to AS2327.1 Section 4 and Appendix F for definition of 'construction stages' and associated construction loads. These loads closely parallel those specified in AS3610 "Formwork for Concrete" but there are some significant differences because of the characteristics of composite decking systems and particularly the large loaded areas for the supporting beams and columns compared to relatively small supported areas with conventional formwork bearers, joists and props.

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- Refer to Clause 4.4.2.4 of the Formwork code AS3610. This recommends designing formwork (prior to pouring concrete) for a 'stacked material load' of 4 kPa factored as a live load – but with no live load reduction - and in combination with the 1 kPa normal construction live load. This high loading is generally not critical for 'normal' formwork because of the higher slab thicknesses for which such formwork must be designed. In this application (with a 120 slab thickness), both the Bondek and its supporting beams at construction stage 3 defined below must be regarded as formwork. If the 4 kPa stacked material live load is applied, this heavy loading is likely to become a critical design case, requiring large and uneconomic steel beams. AS3610 does allow the 'stacked material load' to be deleted from design consideration, provided the allowable loading limits are clearly indicated on drawings and are enforced on site. This design is based only on the 1 kPa construction loading without the additional 4 kPa stacked materials load.

Stage	**Description and assumptions** * Stages 1, 3 and 7 are generally most critical	**<u>Loading on supporting steel structure</u>** Local sheeting loads not considered refer AS2327.1 Sect. 4 and App. F.
0	Steel framework only	Self weight only
1*	Steel framework with formwork (profiled decking) in place. Assume the decking has minimal connection to the steel beams that will be unrestrained against beam buckling. (*Critical stages are shaded)	Self weight plus A 10 kN point load (at mid span) applied to the top flange of the steel beam **OR** Q = 0.5 kPa for A < 23 m^2, Q = 0.5 – [(A – 23) / 23] x 0.2 kPa for A = 23 to 46 m^2 Q = 0.3 kPa for A > 46 m^2
2	Shear studs and reinforcement installed. Assume shear studs are site welded through decking so that the beam top flanges are now continuously restrained against beam buckling. Particular design attention regarding beam stability is essential if studs are welded off site.	As for construction stage 1 plus the reinforcement – typically allow 0.1 kPa per 100 mm of slab thickness. (ie 0.12 kPa)
3*	Placing and finishing the fresh concrete. Again particular design attention to beam stability is required if studs are not welded through the decking.	Self weight plus Q = 1.0 kPa for A < 23 m^2, Q = 1.0 – [(A – 23) / 23] x 0.4 kPa for A = 23 to 46 m^2 Q = 0.6 kPa for A > 46 m^2
4	Concrete curing until concrete strength reaches 15 MPa (generally 7 days). No design implications provided the slab is protected from significant load changes.	The structure should support only self weight during this curing period.
5	Concrete curing until concrete strength reaches full design 28 day strength (generally another 7 days). No design implications during this time.	Self weight plus Q = 1 kPa with live load reduction as above Note that there is no propping.
6	From completion of curing until the end of construction and the commencement of the in service condition.	Note that during this time the superimposed dead load will be installed (partitions and services) in addition to a construction live load of 1 kPa.
7*	In service condition with the building complete – refer to following page	Self weight + superimposed dead load + design live loads (2.5, 3, 4 and 7.5 kPa).

Additional loading information is provided in AS2327.1 Appendix F relevant to 'local' patches of distributed load (due to stacked materials and the like) for which the steel decking must be designed. These small patches of load generally do not affect the design of the supporting steel beams.

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