COMPOSITE CONCRETE SLABS ON STEEL DECKING.
SAFETY IN CONSTRUCTION.

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Summary

In New Zealand the design and construction of concrete slabs on steel decking is a safety issue which needs addressing. It is a regular occurrence to see instances of the decks shifting and moving during construction requiring urgent propping to allow the pour to proceed. It was exactly the same in the UK. This prompted the UK Concrete Society and the Association of Concrete Industrial Flooring Contractors to write a guidance report on the construction and associated design considerations. This “Good Concrete Guide No 5” (GCG5) is titled: “Composite Concrete slabs on steel decking. Guidance on construction and associated design considerations.” It is the aim of this paper to review the issues that led to its writing in the UK, to see if they apply to construction practice on New Zealand sites and recommend where we go from here.

New Zealand Situation

Composite slabs on steel decking fulfill a need and have their place but action is required by all the parties involved to ensure that the design and construction result in safely constructed slabs. While we may not have seen any injuries or fatalities there is a risk they could occur. There are a lot of guidelines available, such as UK Steel Construction Institutes publication “Composite Slabs and Beams using Steel Decking: Best practice for Design and Construction.” Referred to as SCI P300 it is an excellent document downloadable from the web or from local steel deck tray manufacturers websites. But either these publications do not attract engineers and main contractors attention or perhaps they do not focus enough on the construction safety, because while these documents exist and are promoted, safety on metal tray decking remains an issue in the eyes of the concrete placers who have to work on these decks at height.

The local deck manufacturers include construction guidelines with their documentation but these tend to be impractical when it comes to the placing and finishing of the concrete.

How are we going to get the concrete in there? Almost certainly pumped, but not by a boom but by a static line. A static line is very heavy and has to be supported across the deck. A 100mm line is very heavy when full of concrete. Each metre of pipe with concrete is approximately 20kg, so when you are moving the end of the pipe around, say 5m of pipe, it will require two strong men. A good pump will deliver a cubic metre every 60-90 seconds, 2400kg in 60 seconds or the equivalent of a 100kg man every 2.5 seconds. If left unattended for a moment or two or a lot of weight can be deposited in one place.

The good practice guidelines which are currently promoted by the steel deck manufacturers are an ideal but are generally unrealistic and should not be taken as common practice. These following guidelines were sent to Conslab for a recent contract:
• Never heap concrete – As noted above a few seconds inattention can lead to a heap and in a construction environment over a day that can easily happen.

• Place the concrete not more than 300mm from its final place. – When you are trying to wrestle a very heavy line that is moving with every thrust of the pump this is not easy. If you can place directly off a boom pump this would be far more practical.

• Ensure workers observe a 1m working zone. This can be emphasized to staff but when working hard on a site this is practically unrealistic. SCI P300 and GCG5 are far more realistic when they state that “no more than 4 workmen should be present around the pipe outlet during pumping…”

• See-saw concept – Place the concrete either side of a beam to balance the weight. This is extended to the 1/3rd concept where the concrete is placed over the beams extending 1/3rd into the bay before the central 1/3rd is placed. Using a heavy pump line to do this is very hard and in most cases will not happen. It may well require dragging the line and gear back through placed concrete to finish a missing segment.

What is foreseeable is that these are not regular practice on NZ sites.

Conslab's interest in this is one of safety for our staff and those of other placing companies within the construction industry. These slabs are always at height and a fall could easily result in serious injury. Kerry Payne from Christchurch had a large area of tray deck drop during concrete placement. In his words it was extremely lucky no-one was killed. We regularly encounter situations where the metal decking moves under our workers while they are placing the concrete. They have to get off the slab while temporary propping is provided under the slab before they can get back onto the decking. This is not particularly safe for those on the decking or for those who have to put the temporary propping in. Certainly no-one should be working under the decking during concrete placement.

What we see most is rotation of the supporting beams. The steel decking is held with a Ramset nail through the deck to the steel beam. As soon as the beams rotate though we get our men off the decks as this connection detail seems very light to be holding tonnes of concrete and reinforcing.

The UK Approach

In the UK the Metal Cladding and Roofing Manufacturers Association along with the Steel Construction Institute produced SCI P300. It appears that although a comprehensive design guide is available in SCI P300 that certainly the concrete placers in the UK did not feel that it was resulting in safely designed structures under construction loading.

The Association of Concrete Industrial Flooring Contractors decided that a new document focused on construction was the answer. They combined with the UK Concrete Society to write “Composite Concrete slabs on steel decking. Guidance on construction and associated design considerations.”
This guideline does not replace SCI P300. As GCG5 notes: “It is intended to complement SCI P300 by providing designers and contractors with an overview of the factors which need to be considered. It is expected that as long as the issues raised in this guideline are carefully considered in the design and construction process then the result will be safely constructed slabs with good service performance.”

Moving Forward

Arriving at a safer process will require a pan industry approach and education as well as documentation but the UK have at least produced the documentation and it is an option that we can use it.

But given that we have SCI P300 on the web and SCINZ has papers on floor tolerances is yet another guideline required? Will another guideline raise the awareness of the issues to New Zealand engineers and main contractors?

GCG5 was written in the UK exactly because it was felt the other documents available didn’t focus enough on the elements that lead to construction safety. It picks up on those other matters where common practice, such as specifying U3 to NZS3114:1987, are leading to issues. Certainly what is available now is not producing the desired outcomes through either a lack of knowledge of the documents or a lack of application. From a design perspective these floors seem so easy that perhaps they don’t receive the attention to detailing that they should. Let us not wait for an incident to be the prompt that brings that attention. This document and the issues highlighted within it need to be better known throughout the construction industry. It is most likely a combination of this guideline and education that will bring about the required lift in safety and understanding of the tolerances achievable in composite concrete slabs on steel decking. With limited work required to bring this reference New Zealand documents this guideline would be a good start.

Generally the various bodies are supportive of the idea. The Master Concrete Placers Association was very supportive and a prompt answer came back along with a photo of just such an instance where the metal decking has dropped.

CCANZ have been supportive and approached the steel industry body HERA to ascertain their reaction. They were also supportive so it appears we have the necessary bodies interest to ensure we could produce a New Zealand version of the document. Dr Stephen Hicks from Hera actually worked on SCI P300 so we have the experts with the knowledge.

To be able to take this on as a guideline in NZ we require the agreement of the UK Concrete Society and the Association of Industrial Flooring Contractors, ACIFC. We do have confirmation from the chairman of the committee which wrote this guideline that this would not pose a problem but we would need to get formal agreement from the two associations.

What’s in the Good Concrete Guide?

The guideline is essentially split into three sections; Design and specification, Construction and Post construction and in-service issues. Being written in the UK it does not touch on seismic issues. However the emphasis of the guide is on the process of designing for safe construction and realistic tolerances and the requirements of seismic design are well catered for elsewhere.

They do refer to British standards throughout the guideline and in particular BS 5950 part 4 which is the Code of Practice for design of composite slabs with profiled steel sheeting and also the SCI P300 which as noted above you can access easily here in NZ through steel
decking suppliers in the market. If we wished to pick up this document we could simply replace these references with the NZ/AS equivalent.

The Design and Specification section starts with a Designers checklist. It is here where they start to point out the issues around flatness and levelness tolerances with regards the British specification BS8204. They note that; “...tight slab level and flatness specifications will not normally be achievable on conventional composite slabs, and should not be specified unless absolutely necessary.”

Later in Chapter 2 under tolerances they have a table where they reference relationship to datum, 15mm as opposed to NZ’s 10mm in the Concrete Construction Standard NZS3109 Table 5.2 and suggest this should only apply around columns and not out in mid-span. Clarke and Hyland, 2008, wrote a paper “Suspended Slabs level Tolerances” where they suggest a greater tolerance. Their conclusion is that the level of the top surface of a floor “shall fall within a +/-20mm envelope and as levelness varies in time, measurements must be made within 72 hours and before removal of any propping to show compliance with the specification.”

The following table is taken from SCI P300.

<table>
<thead>
<tr>
<th>BS 8204 Flatness Designation</th>
<th>Maximum gap (mm) below a 2 m straight edge laid on the surface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR1</td>
<td>3 (1 in 667)</td>
<td>Not achievable on suspended floors of any construction.</td>
</tr>
<tr>
<td>SR2</td>
<td>5 (1 in 400)</td>
<td>May be achievable on parts of a composite floor, but will not be achievable over all of a floor, owing to deflections. This is a tight flatness tolerance and high levels of workmanship are required to achieve SR2 on any type of suspended floor.</td>
</tr>
<tr>
<td>SR3</td>
<td>10 (1 in 200)</td>
<td>May be achievable over most of a floor, depending on the deflections of the supporting beams.</td>
</tr>
</tbody>
</table>

This table highlights that the New Zealand code which specifies surface tolerances on slabs NZS3114:1987 is not realistic for suspended slabs. NZS3114:1987 uses a 3m straightedge (compared with the British 2m straightedge). A 3mm deviation is called up where covered with thin sheet tiles giving a 1 in 1000 slope. As shown in the table it is considered that 1 in 667 is considered unachievable.

If we use 5mm, which is specified in NZS3114 for where the floor is to be covered with leveling compound or carpet this is still 1 in 600 which while not achievable is commonly specified. SCI P300 suggests 10mm under a 2m straightedge may be achievable. Perception in NZ would be that 10mm in 2m was rough whereas those tasked with measuring these floors consider it may be achievable.

U3, while also being a type of finish, is a very tight slab level specification and probably only the abrupt deviation criteria should be specified. It would be a step forward for New Zealand if the finish and flatness and levelness tolerances were separated from each other.

GCG5 also notes that the effects of laps in bar and mesh reinforcement on cover need to be taken into account. We are regularly having to lift the top surface of the concrete to provide a nominal cover to the reinforcement which again affects flatness.
Chapter 3 on Construction is the section which Conslab believe makes this guideline most valuable.

As is so often the case it is the communication between all parties involved which is most important. You can have a steel decking supplier within a steelwork sub-contract package, a main contractor and a concrete subcontractor. Everyone must understand the assumptions used in the design and who is responsible for each step in the construction process. Our view is that the requirements must be on the drawings so that it is clear in the site sheds what is required for safe construction.

GCG5 suggests that unless absolutely necessary temporary propping should be avoided as they can led to safety and construction problems, and, unless absolutely necessary, design the slab to avoid the “imposition of complex and impractical sequences for the casting of the concrete on the decking.” But also that:” Generally decking is designed as double span for the condition of construction loading. Thus single spans may need to be propped …..and it is imperative that this is communicated clearly to the main contractor and concrete contractor.”

The method for leveling the concrete has to be understood. Often the concrete is poured to constant thickness with pins set to give a constant thickness above the metal decking. Excluding issues with reinforcement cover and edge boxing at different levels this gives good control on the concrete thickness but less control on the surface profile.

A variation is to have pins set to what is expected to be the final level on the beams. These will still drop as the load is applied but less so than the constant thickness approach. This will require additional concrete to cater for the deflection and it must be noted that the finished levels will not be the same as when the levels were set. Additionally as the pour progresses the beams and deck will continue to creep downwards so that concrete poured earlier will have settled below the initial datum. This cannot be corrected otherwise you continue adding concrete up until failure.

Finally we can try to pour to a constant set level using a staff and level. Deflection of the decking and beams as the pour proceeds does mean that the level will still vary from what is expected. This process can give rise to an increase in the concrete volume and thickness.

A final point is that all concrete needs to be cured and in reality the only practical approach is a curing membrane. However a code compliant membrane is not going to let the slab dry and thus will almost certainly give rise to moisture issues with carpets and other coverings. Probably the only practical approach is to use the various proprietary silicates available on the market. Despite what is claimed any rigorous assessment of their testing shows they do not comply with the codes, although they certainly beat doing nothing.

Finally

Designers must give attention to foreseeable construction safety and not just the final design. SCI P300 notes that designers can assume that the concrete placers are “experienced specialists who are aware of the hazards of working at height, and used to managing the risk by adopting best practice in laying techniques.” This reads like a statement to be used in court once an incident has occurred. In a tender environment where main contractors win by getting lowest possible prices from sub-contractors there will be many instances of inexperienced and untrained placing sub-contractors working on metal decking floors.

GCG5 takes into account the practicalities of working with concrete. It highlights the communication that is necessary between the designer and the contractors so that important design considerations are transmitted to the construction team. It also picks up on the
flatness and relationship to datum tolerances that are achievable on composite steel deck flooring. NZS3114:1987 is woefully inadequate when it comes to elevated slabs.

So in essence GCG5 complements SCI P300 by highlighting those areas where the concrete placing industry see the current processes and design guides not producing safe construction designs. As well it picks up on a couple of other issues such as tolerances that are unachievable.

Adopting the Good Concrete Guide “Composite Concrete slabs on steel decking. Guidance on construction and associated design considerations.” would seem to be a practical step on the path to improving the safety of New Zealand Construction sites.