SMEC South Africa
Member of the Surbana Jurong Group

Implication of Constructing the New Umhlatuzana River Bridge Deck Monolithically with the Existing Deck

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Agenda

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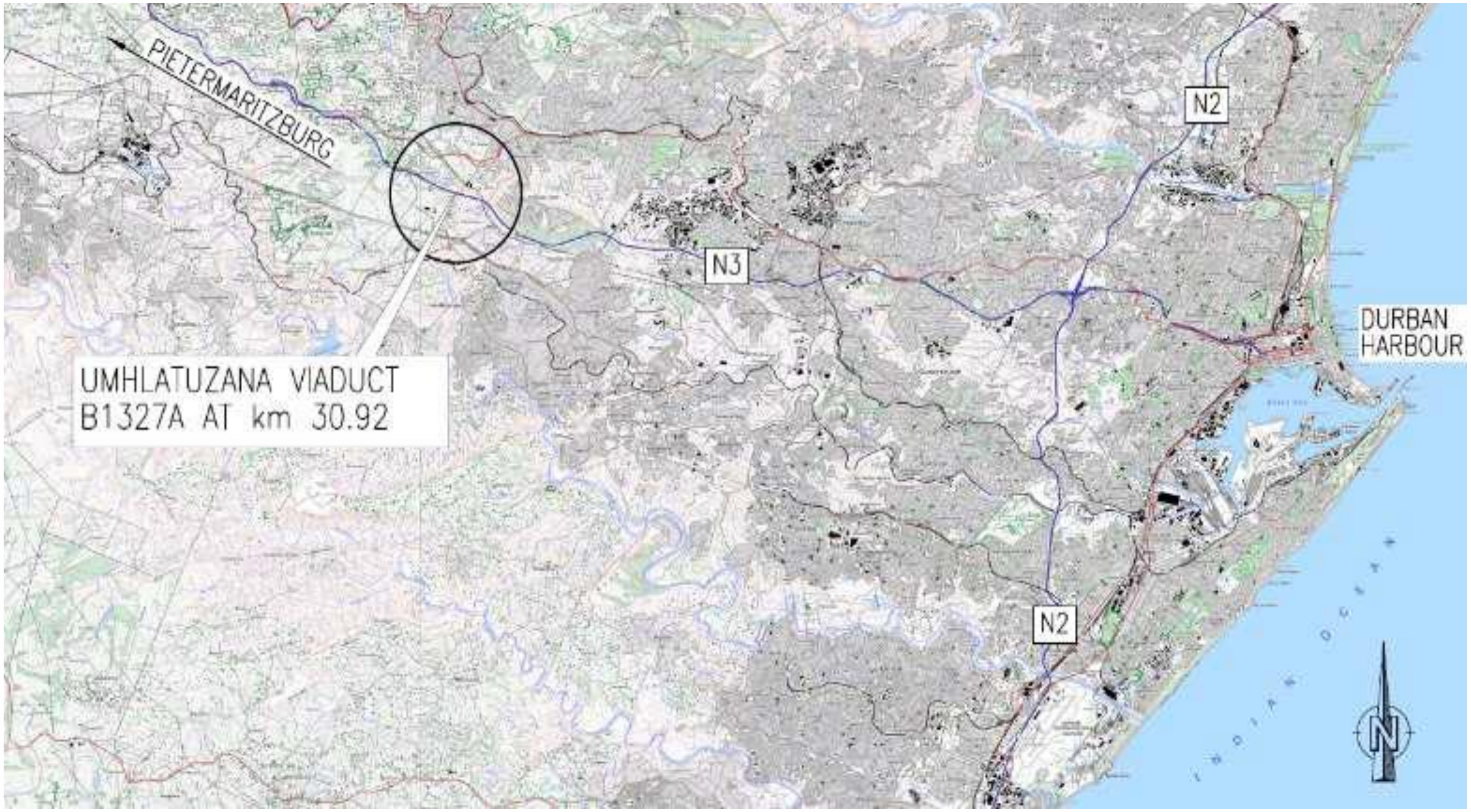
2. Introduction
3. Proposed Widening
4. Connection Options
5. Creep and Shrinkage
6. FEM Model
7. Modeling Method
8. Results
9. Conclusions and Recommendations

Existing Bridges

Existing Bridges

Location of the Bridges



Introduction

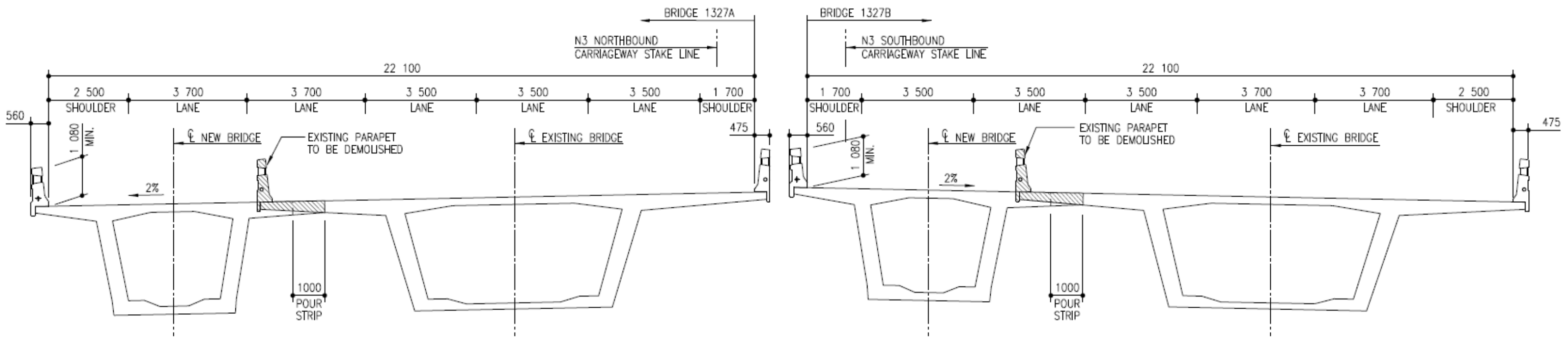
Two existing Umhlatuzana Bridges with the following properties:

- 413 m long;
- 47 m main spans with 40 m back spans;
- Deck widths of 15.1 m;
- Both bridges constructed originally via Incrementally Launched Method (ILM);
- Original construction completed in 1985.

New decks are constructed alongside existing:

- Narrower deck – 7.4m;
- Same span layout as original;
- Also constructed using ILM

Proposed Widening



The Problem?

The new deck once constructed will be 40 years younger than the old.

As both decks are prestressed they both undergo Creep & Shrinkage.

But at different rates.

Hence, they will shorten at different rates.

In fact the old deck has almost undergone all its shortening.

QUESTION?

How will the new decks be connected?

Options Considered

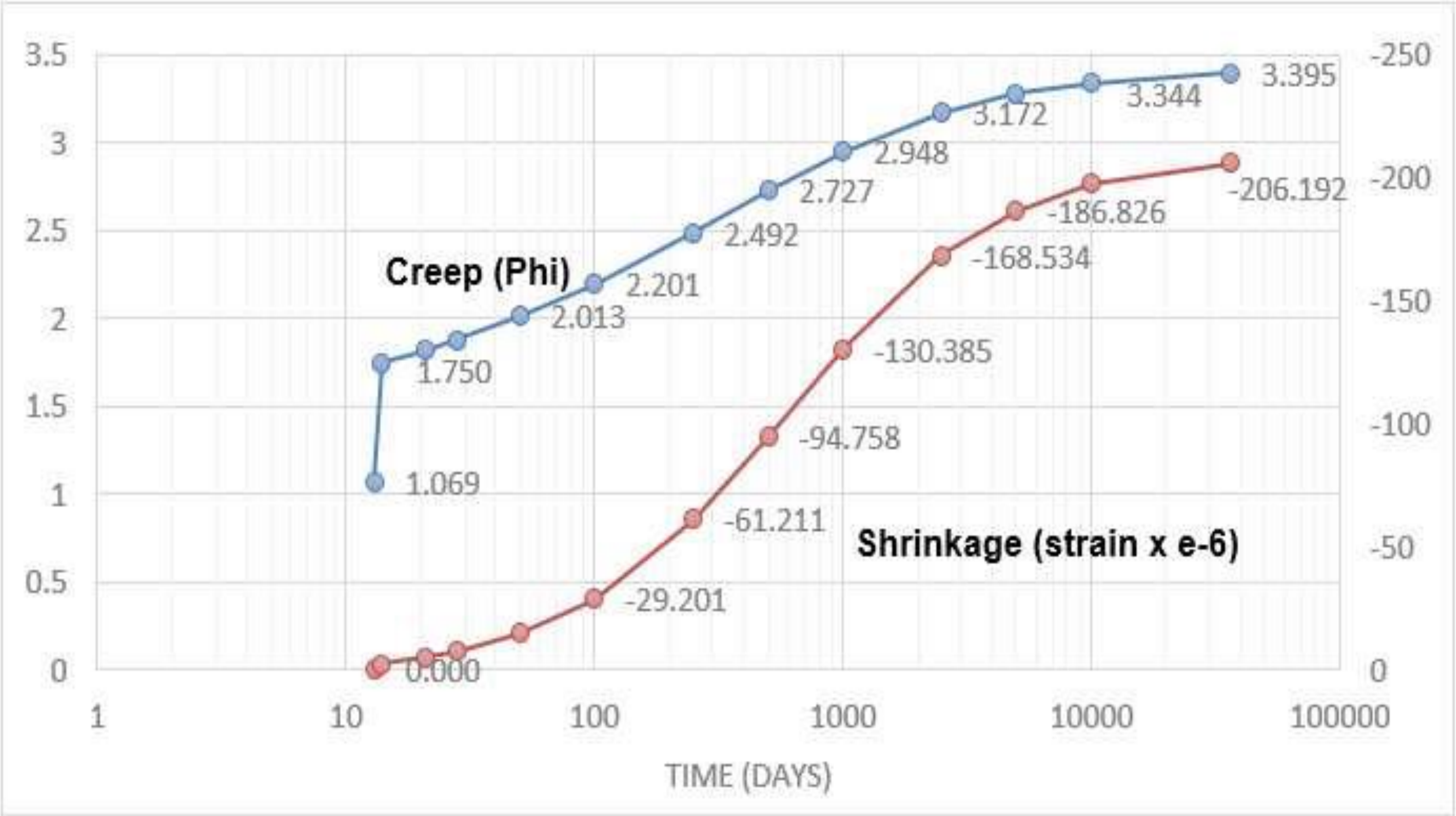
Longitudinal Joint

- This would be positioned in the middle of the travelled way
- A gland and claw joint would be most suited
- Due to the metal runner, skidding of vehicles over the joint is a problem and can lead to accidents

In – situ stitch

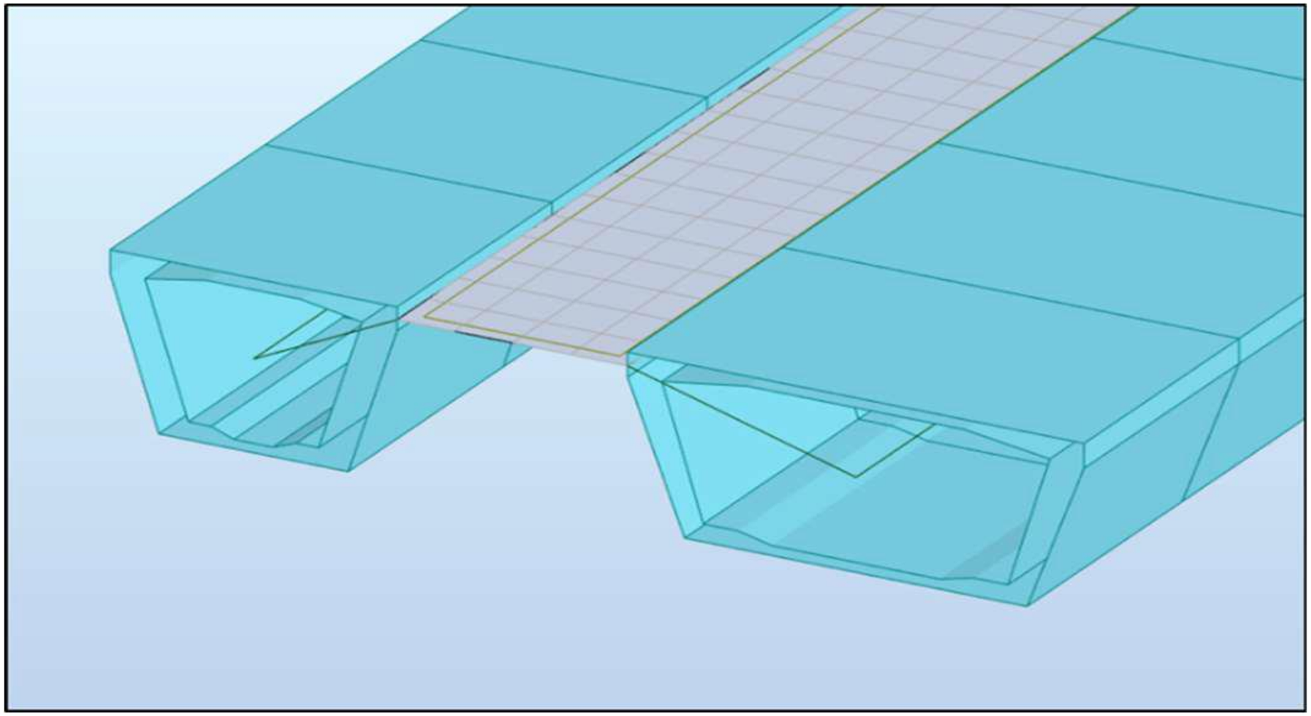
- This option solves the above problems
- The key issue is how to deal with differential movement of the two decks
- This is the subject of this paper

Creep and Shrinkage



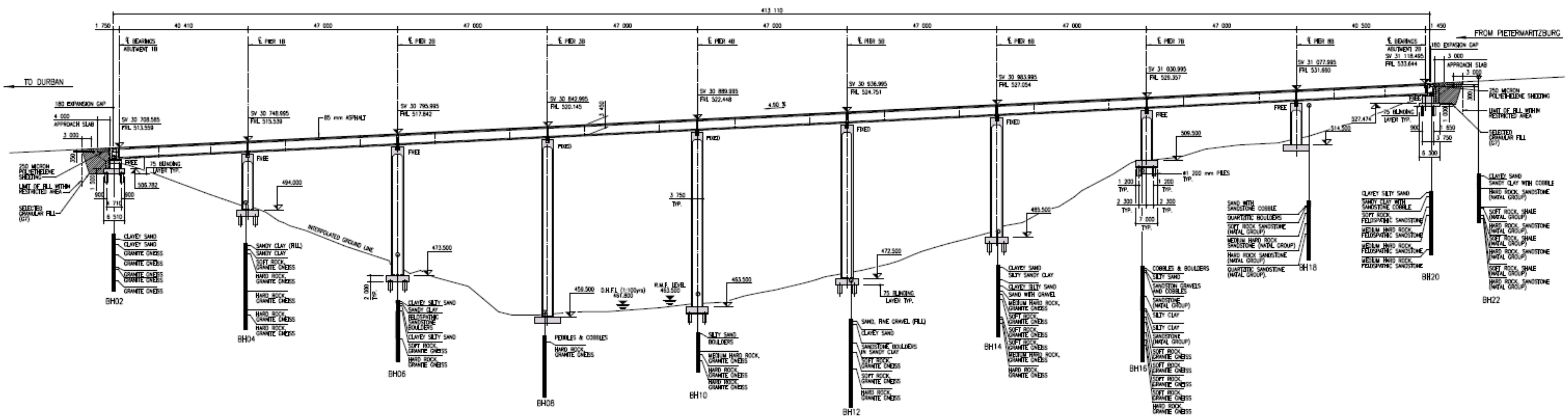
Model

- An FEM model was created that included beam elements that modelled the box girders
- Shell elements were used to model the connecting slab and connected to the box.



Fixity

- Existing bridges are fixed at the Northern Abutment
- Change fixity to the central piers



LONGITUDINAL SECTION ALONG ℄ NEW BOX GIRDER B1327B
SCALE 1:500

Stitch

Modelling Method

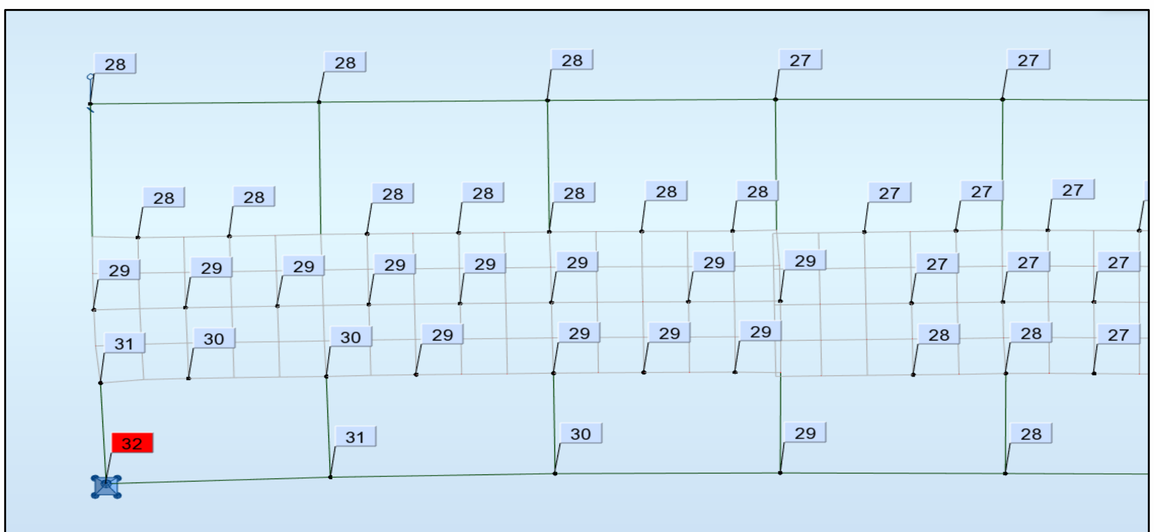
Calculations of strains for the new deck:

- Stress in the deck due to prestress – launching and draped cables
- Strain calculation from creep and shrinkage
- The decks will be left unconnected for 4 months so that as much creep and shrinkage will take place prior to joining the decks.
- The advantage of ILM is that most of the prestress force comes from launching tendons which are older than the draped cables

Once the strains were calculated, they were applied as equivalent temperature loads to the beam elements in the FEM model.

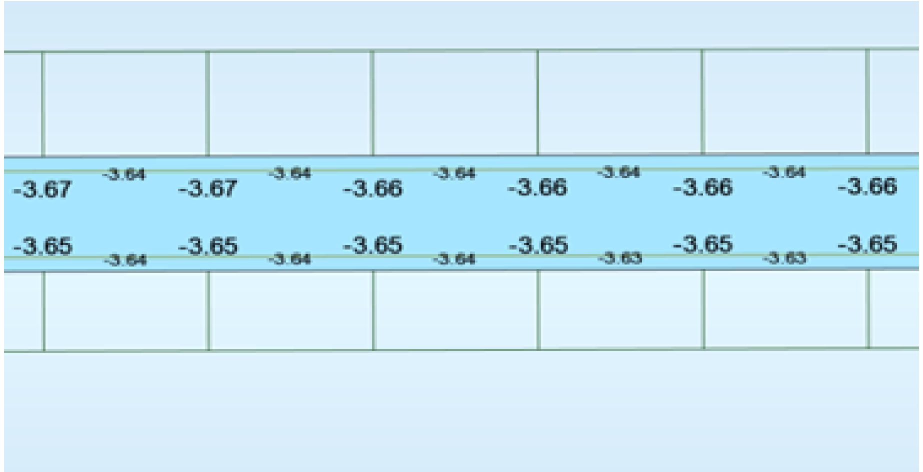
Results -Movement

- The unrestrained difference in movement between two decks due to creep and shrinkage = 64 mm
- The below image shows the actual movements of the decks.



Results – Middle Deck Stresses

- Principle stress 2 is primarily in the longitudinal direction
- Approximately 4 MPa compression (Principle Stress 2)
- Principle stress 1 is 0 Mpa (Transverse direction).



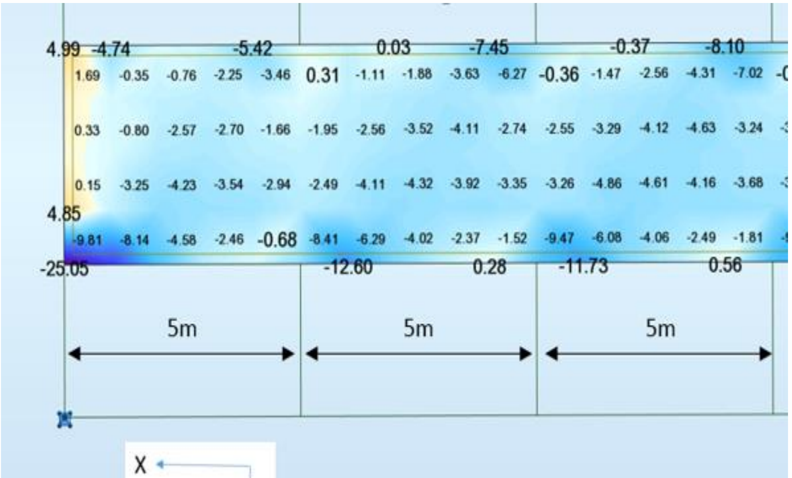
Results – End Deck Stresses

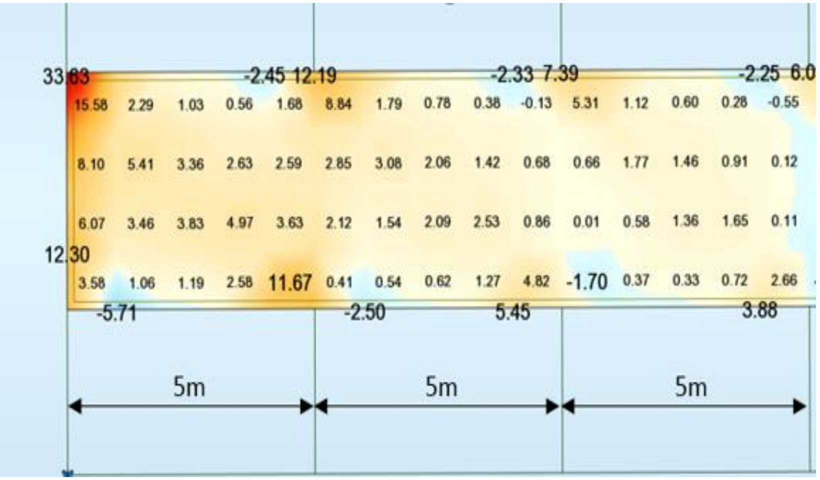
Principle stresses 2

- Section largely in compression
- Small amount of tension in bottom corner

Principle stresses 1

- Section largely in tension
- Peak stress 15 Mpa but reduces to approx. 1 Mpa (Tension)





Results – End Deck Stresses

- The tensile stresses are above the tensile limit of the concrete
- Impractical amounts of reinforcement required to counter these stresses

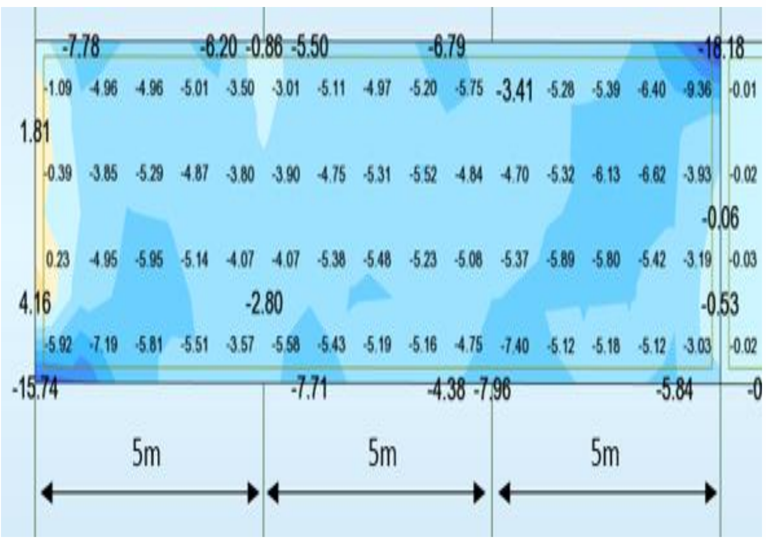
The following is proposed:

- Thicken the connection slab to 1m depth for the final 15 m of deck
- Prestress the thickened section transversely (5 Mpa)

Results – End Deck Stresses (5MPa)

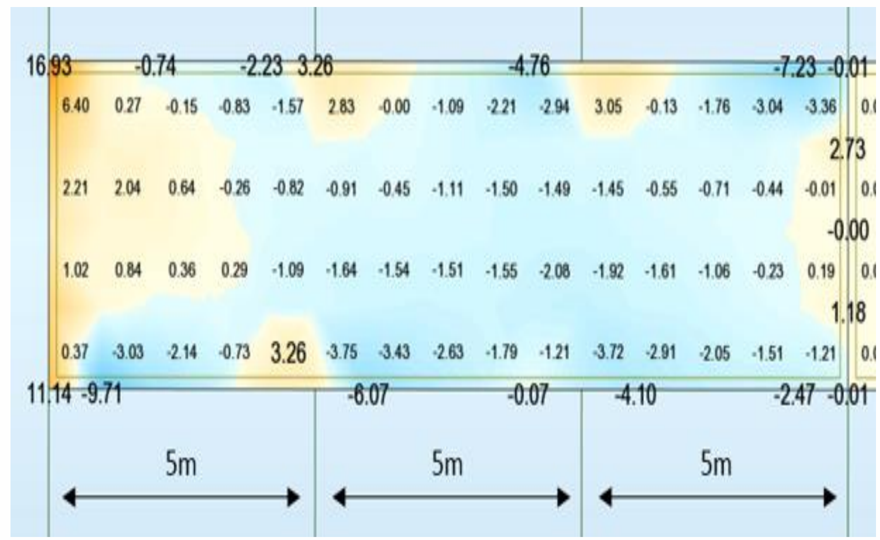
Principle stresses 2

- Compression stresses are well bellow the compression limit for concrete



Principle stresses 1

- Section mostly in compression
- Small sections in tension however below cracking limit of concrete



Conclusions and Recommendations

- Differential Creep and Shrinkage plays a major role as the two decks shorten at different rates
- Delaying the connection of the decks once the prestressing is installed reduces the differential movement substantially
- Due to differential creep and shrinkage, the existing deck goes into compression whereas the new deck goes into tension.
- The overall movement of the decks reduced which allows for smaller expansion joints
- The stresses in the connecting slab in the middle of the bridge deck were mostly in compression with the stresses easily accounted for by the stitch slab
- Tension at the deck ends was evident. However, prestressing the deck transversely reduced the stresses.

Final Notes

- Stitching decks of this length is largely experimental
- We are not aware of connecting slabs of this length been done before
- The risks have however been evaluated and will be confined to some cracking in the connecting slab at the supports
- Self healing concrete is proposed
- Galvanised reinforcement across the stitch is required

Thank you