# Analysis on Different Modelling Aspects For The Design of Bridges

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***Abstract-*** *Current practice for the designing of the reinforced concrete bridge which is based on the linear elastic structural analysis for the sectional distribution of the loading on the bridges is sought out. In this analysis the various directional forces i.e. longitudinal and transverse direction of forces is to be analyzed by using three dimensional (3D) models.*

*The different modeling technique is established for the designing of the reinforced concrete bridges. Even though the different modeling technique is available that is modeling by software or by manual calculation. This thesis investigates the different methods adopted for the 3D analysis of the reinforced concrete bridge. The aim is to illustrate the different modeling procedure and the choices made for the modeling procedure that has resulting design of the bridge.*

*Case study has been performed where different modeling methods was researched. Various models have been laid out and the outcomes from primary examinations thought about. Resulting sectional forces and reinforcement design show just little contrasts between various modeling strategies. The outcomes show that the decision of underlying model for investigation at a design stage little affects the outcomes. Up to a structural model doesn't present blunders in that frame of mind of the reaction, other boundaries are a higher priority than the exactness in the model. Such boundaries are for instance ease of use, evidence and understanding of results.*

*The outcomes likewise show that there is an absence of laid out methodology and rules for modeling and check. Such rules would improve on the work for engineers while laying out structural analysis models and set the foundation for coordinated effort furthermore, normal working methodology inside the industry.*

***Keywords***- Structural analysis, design of bridges, concrete structures, finite element analysis, modelling procedures, 3D analysis, Brigade/Plus, Abaqus CAE

## I. INTRODUCTION

Plan of built up reinforced concrete bridges is ordinarily done based on an underlying investigation. The reason for the examination is to find a dispersion of sectional powers which satisfies harmony and is appropriate for plan. In the past primary investigations were frequently finished with improved on models, for instance two-dimensional (2D) comparable bar or edge models. Such a model can't portray the dispersion of powers in cross-over ways. Subsequently a plan as per a 2D comparable model won't be as indicated by the genuine direct flexible circulation, despite the fact that the plan may satisfy necessities in extreme breaking point state (ULS) after adequate plastic reallocation.

With the new presentation of Euro code and the Swedish Transport Administrations, Trafikverkets, new specialized prerequisites for bridges TK Bro, Trafikverket (2009a), the requests on underlying examination has been refreshed. A model for primary examination must have the option to portray the reaction of the design completely. By and by this infers that 2D comparable models are not adequate and a 3D examination depicting the powers in different ways is required.

Despite the fact that 3D-models have been utilized for plan of bridges to a shifting degree for a long while, it is as of late that it really has been set as a prerequisite. To adapt to these requests new strategies are utilized for underlying examination. For the most part these strategies are more complex and progressed for example 3D Finite Element(FE) models, where the creator has huge opportunity in building the model. The decisions accessible in the demonstrating technique are huge; consequently a similar design can be displayed in more ways than one.

Today there are no reasonable rules for fashioners while setting up 3D-models, which presents issues since the effect of decisions made during demonstrating stage has not been as expected examined. This postulation pointed towards researching and enlightening a few impacts these decisions in building up an underlying model may have on the plan of a design. The review was centred around reinforced concrete street bridges, however a few of the ideas and demonstrating techniques are general and ought to be appropriate to different kinds of reinforced concrete constructions.

**Limitations**

The bridges displayed in the proposition are exposed to an improved on mix of loads in a definitive breaking point state. These loads incorporate;

- Self-weight and surfacing
- Shrinkage
- Earth pressure, including earth pressure increase due to horizontal loading
- Surcharge
- Uniform temperature change and temperature gradient on superstructure.
- Traffic loads, load models 1 and 2 according to Euro code including lateral and horizontal loading due to acceleration and braking
- Wind load

Load mixes remembered for the investigations incorporate load blend for ULS as utilized in plan of bridges in Sweden. Since the current practice in plan of reinforced concrete bridges includes direct flexible examination, non-straight investigation won't be remembered for the proposition.

The proposal has for time-requirement reasons been restricted to investigation of the superstructure as it were. Estimation of required support sums has been performed for the principle support in longitudinal and cross over ways. The base has been remembered for the concentrated on models, however results from base development components have not been dissected.

## II. LITERATURE REVIEW

**F. Masoumi, F. Akgül, and A. Mehrabzadeh. (December 2013)**

In certain nations, the breakdown of bridges started the proper necessities for the assessment of roadway spans. Practically in totally created nations, the executive frameworks have been produced for savvy distribution of restricted financial plans for crumbling spans. Visual examinations are one of the main aspects of a bridge for the executive's framework. Then again, numerous new and promising procedures for the non-damaging assessment (NDE) of parkway spans have arisen in the previous many years. NDT techniques are expensive and tedious too; since they can't be utilized broadly in span the board frameworks. Notwithstanding, NDT strategies can be utilized as the check of visual assessments span the board frameworks. This study examines visual assessments of 200 supported substantial extensions in Turkey and non-ruinous testing applications performed on 10 generally inadequate bridges. Infiltration opposition, ultrasonic heartbeat speed, rebar finding, and support consumption tests are performed on decks, docks, and light emissions substantial extensions, and the outcomes are contrasted and the consequences of visual assessments.

**Joshua T. Hewes. (October 2013)**

Precasting of extension base parts holds potential for speeding up the development of bridges, lessening effects on the voyaging public on courses neighboring building destinations, further developing bridge solidness and thus administration life, and diminishing the natural effects that are related to cast-in-place development activities. The utilization of precast cement foundations has been restricted in the United States; as of late have state branches of transportation (DOTs) created and carried out advancements that speed development using pre-assembled sections, cap radiates, and footings. In this exploration, the creator assembled important data on the utilization of precast bases by state DOTs and broke down existing advances for the fittingness of utilization on common extensions inside Arizona. Drawing from the gathered writing, the writer makes suggestions for executing precast bases.

**Ramyasri. N, Rangarao. V. (January 2017)**

In this study pre-focused on the substantial bridge is investigated utilizing STAAD-Pro by considering heap establishment at focus and closes projection is taken as fixed. Here, two models have contrasted one and soil collaboration and the other without soil connection. Moving loads are given 3 stacking cases for example class-A, 70R followed, 70R wheeled loadings. Discoveries: Soil structure connection is an incorporative review that incorporates the geotechnical and primary design. Change in soil property around the heaps and beneath the projection doesn't influence the exhibition of the super construction. The construction plan, Foundation plans are determined by disregarding soil firmness. In plan, ignoring communication impacts among soil and bridge may result whether it is risky or expensive. The enormous vulnerability while planning the PSC spans is at heap establishment because of the response of the soil. The response of sidelong soil is nonlinear. Bridge and the supporting soils are analyzed as one viable unit in soil communication. For the above reason, soil properties are considered in the examination and plan of the dirt design framework to guarantee a solid and conservative plan. Enhancements: Effects of soil on projection for 3 stacking cases which are upheld by the shallow establishment rather than the proper end.

**Tarek Omar and Moncef L. Nehdi (September 2018)**

Bridge condition evaluation techniques have existed for a long time. It was illuminating to understand the degree of progressing work that is extending quickly considering the faltering assets expected to fix maturing spans, which regularly surpass the abilities of bridge proprietors. BCA is a logical and specialized strategy pointed toward creating proof of bridge wellbeing, evaluating its underlying dependability, and fitting systems to delay its life. As per this structure, this review has given a truly necessary survey of late exploration achievements in this field. Future examination ought to consider information that drives the dynamic of bridge proprietors from research wanting to execution, with a specific spotlight on added esteem. Really at that time can the utilization of these advances in standard extension designing practice was significant. Inventive plan and development techniques ought to be considered by transportation proprietors alongside updating existing BMSs to consolidate late exploration. A strategy ought to be utilized solely after a cautious money-saving advantage investigation to decide its worth in both the short-and long haul. Ultimately, the tremendous measure of data and information that has effectively been created in the BCA field should be coordinated into far-reaching dynamic frameworks, which could be utilized by different members in the field for quality administration and underlying appraisal motivations behind maturing spans.

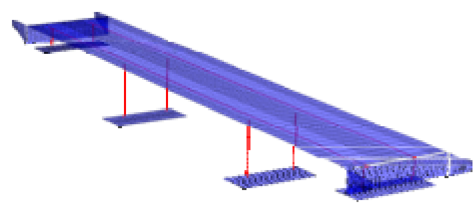
## III. STRUCTURAL ANALYSIS OF CONCRETE BRIDGES

In the current European plan code for substantial constructions, Eurocode 2, SS-EN 1992-2 (2005), four instances of strategies for primary examination are introduced. These are:

- Linear elastic analysis
- Linear elastic analysis with limited redistribution
- Plastic analysis
- Non-linear analysis

Out of these strategies it is just the non-direct which is fit for exact forecast of the reaction during stacking and portray the mind boggling power reallocation occurring when breaking of concrete and yielding of support happens, Engström (2011a). This implies that it is just the non-direct examination which precisely predicts the conduct of the design in help state, and the method of extreme disappointment. Notwithstanding, the non-direct examination requires considerable exertion in foundation and post-handling of the model, just as an enormous computational exertion. It likewise requires the information on the total format of the construction in advance, making it a technique appropriate for exact appraisal of existing designs however not reasonable for configuration purposes since this information isn't accessible at a plan stage. One more significant disadvantage for non-straight demonstrating in a plan phase of built up substantial bridges is that non-direct investigation doesn't consider load superposition. For bridge plan applications with a wide range of loads and load mixes it is fundamental according to a functional perspective that load superposition is conceivable.

Underlying components depend on the situations of for instance bar and plate hypothesis. This makes primary components reasonable for plan since they give sectional forces straightforwardly to each cross-area. Underlying components likewise takes into consideration a less complex and more instinctive demonstrating process, see Figure 3.2.



Example of finite element structural analysis model of a double beam bridge. Beam elements shown as lines (red) represent main beams and columns, shell elements shown as surfaces (blue) represent bridge deck, end shields, wing walls and foundation slabs.

**Element mesh**

The limited component network should be adequately thick to catch the appropriate reaction of the construction. A common guideline of thumb says that the component size for shell components ought to be equivalent to or more modest than the thickness of the components.

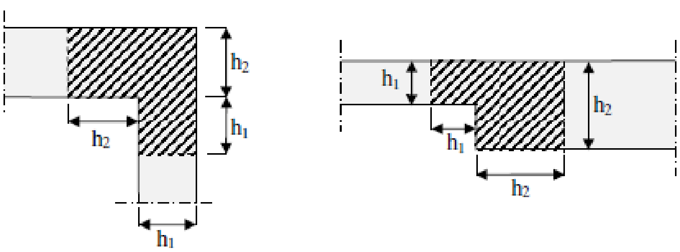
Close to basic areas there must be an adequate measure of components between particular pinnacle esteems (like stuck associations) and the basic segment. Cross section reliance reads have shown that for various lattices the distinction in outcomes is little just a single component away from the pinnacle worth and two components away it is immaterial, Davidson, (2003) and Sustainable Bridges (2007).

**Structural element types**

As expressed previously, underlying components are reasonable for primary investigation in a plan phase of bridges and constructions since the yield (sectional powers) takes into consideration straightforward and natural plan of the design. Underlying components are likewise somewhat compelling at portraying the activities of the construction, which is significant for investigation of bridge structures where configuration codes requires examination of a few load cases, positions and load blends.

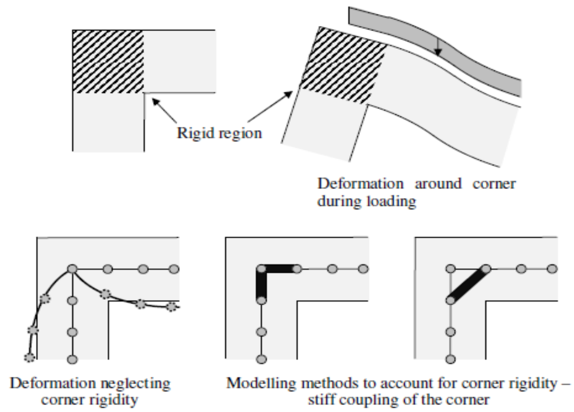
**Discontinuity regions and frame corners**

An underlying framework can be partitioned into B- and D- areas. This is done to recognize regions in a design where the condition of strain veer from the plane strain presumption (Bernoulli speculation) under which bar and plate hypothesis are substantial. Henceforth, D-districts (or brokenness locales) are regions in a design where the strains at this point don't stay straight over the cross-area, see Figure.




**Examples of discontinuity regions, D-regions, where the strain distribution will differ from the linear strain distribution predicted by beam theory.**
**The extent of the discontinuity is often assumed to be equal to the width of the element.**

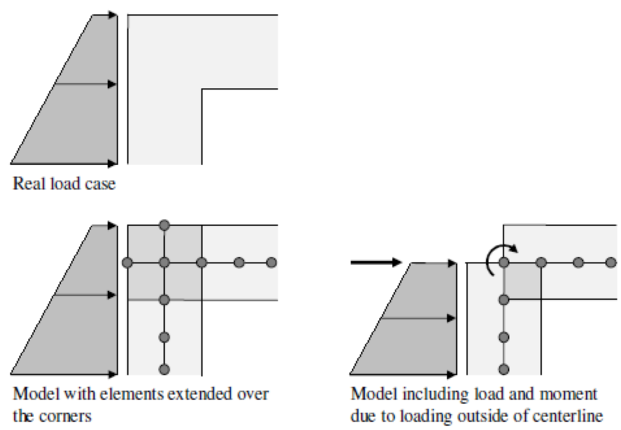
These areas may influence the reaction locally, yet the demonstrating of them is likewise critical to accurately evaluate the reaction around the world. In for instance a casing corner, see Figure 5.2, the strain dispersion no longer remaining parts direct and, when demonstrated exhaustively, the components inside the corner can't move autonomously of one another. Regularly the middle line is demonstrated with bar or shell components and, since the corner pretty much acts like a stomach, its solidness becomes belittled. Subsequently the components inside the corner district ought to be coupled to mimic this impact.




**Response of a frame corner during loading and the response of a model neglecting frame corner rigidity. Alternative models for accounting frame corner rigidity are also shown, Load application**

When stacked against a corner area, an underlying model addressed by part centre lines won't represent stacking outside of the centre lines, for instance outline corners..

- Extending components over the corner
- Adding guide load and second toward represent load and capriciousness of load.




**Different models for bookkeeping stacking outside of centre lines.**

On a basic level both should represent the load adequately well, however the two has their troubles. While expanding the components over the corner one must be cautious when characterizing the component properties so they don't impact the underlying reaction. This turns out to be progressively hard for 3D-models where stiffness in various ways must be dealt with. Adding point loads and minutes makes the load definition more intricate, with expanded dangers for mistakes.

**Layout and geometry of studied bridge**

The bridge comprises of a parkway – walk-and bike pathway crossing. It is arranged outside of the town Umeå, on the east shoreline of northern Sweden.

The concentrated on bridge has a shut establishment section and is established straightforwardly on the ground. The top slab framing the bridge deck is circularly haunched the longitudinal way and cambered by 2.5 % the cross-over way, thus a part in the center of the bridge is around 0.18 m thicker than a segment close to the edge pillar. It has a free opening of 5 m, is 13.6 – 14.1 m wide and the dividers have a normal stature of 4m. Thicknesses of the primary parts is introduced in Table 6.1.

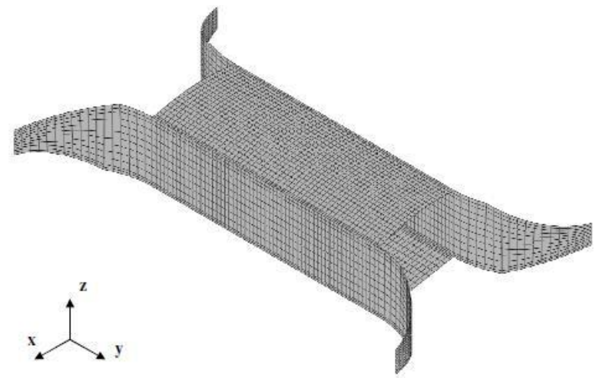
Table over thicknesses for structural members. Varying thickness of the bridge deck is due to the circular haunch and 2.5 % camber of bridge deck surface.

| Structural part | Thickness |
|---|---|
| Foundation slab | 450 mm |
| Frame walls * | 400 mm |
| Wing walls | 450 mm |
| Bridge deck at walls | 740 mm – 920 mm |
| in midspan | 240 mm – 420 mm |

Modeling

3D shell components with thicknesses characterized by Table were utilized to demonstrate the math of the bridge,. The differing thickness of the bridge deck was characterized by a logical articulation utilizing the "Insightful field" apparatus in Brigade/Plus. The component size was picked to 0.25 by 0.25 m in the deck and 0.4 by 0.4 in the leftover pieces of the bridge. This is as per the basic guideline of thumb that the component size ought not be picked bigger than the thickness.

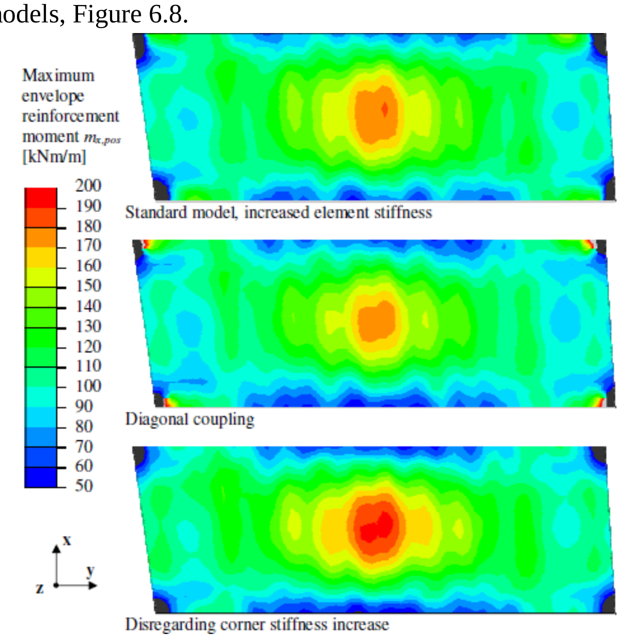
Since the review depended on straight flexible material properties the model depended on uncracked gross substantial segments. The material properties was thusly set to C35/45 cement with modulus of flexibility 34 GPa, poissons proportion 0.2 and coefficient of warm extension 10-5.




Visualization of the integral slab bridge model studied. The bridge is modelled with 3D-shell elements and is here shown in an isometric perspective.

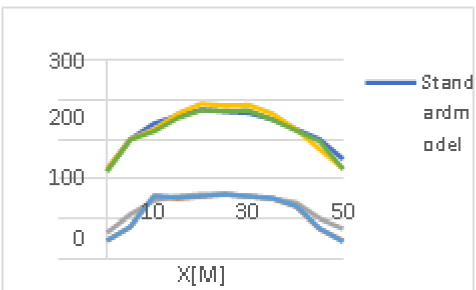
## IV. RESULT AND DISCUSSION

**Primary reinforcement moment in the bridge deck** Contrasts between the support minutes were in accordance with what was generally anticipated; immaterial to no distinctions was found for the all-out responses, while a few contrasts could be seen between the appropriations of minutes. In the most extreme envelope of support second, opposed by base support, the second in the field segment 3-3 was marginally lower for the model representing the corner solidness, Figure 6.7 to Figure 6.9. Be that as it may, for the base envelope of support second, opposed by topsupport, the second was marginally higher in the help segments for these models, Figure 6.8.

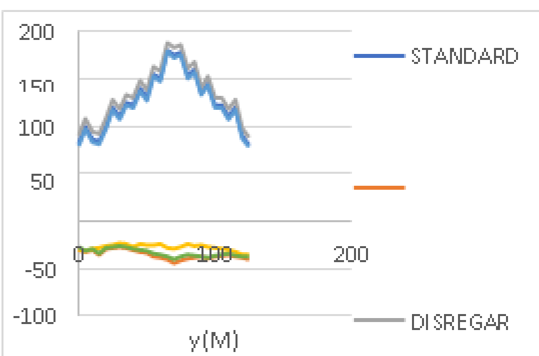



**Maximum envelope reinforcement moment in the bridge deck (resisted by bottom reinforcement). Corner stiffness modelled with increased material stiffness (top), corner nodes in the critical sections coupled diagonally (middle) and corner stiffness increase neglected (bottom). Local peak values due to torsion near the slabs corners are not shown.**

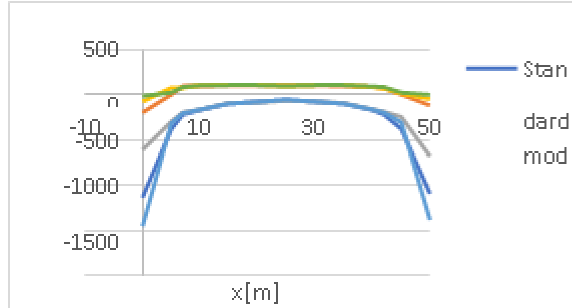
In segment 1-1, midspan area see Figure 6.5, for the base envelope, Figure 6.8, the support second was higher for the models representing an expanded corner rotational solidness. This wandered from the normal outcomes since stiffer corners ought to draw in greater second, decreasing the field area second. Be that as it may, it tends to be clarified since the great impact of extremely durable loads, for example, self-weight is more generous for the model dismissing the corner firmness. When joined with super durable loads, the impact of loads acting troublesome in the base envelope will be diminished, for example ideal impacts in the base envelope of extremely durable loads are bigger for the models with ignoring corner solidness. At the point when individual load cases were concentrated on the minutes in waists were higher (positive or negative bowing) for all load situations while ignoring the expanded corner solidness.



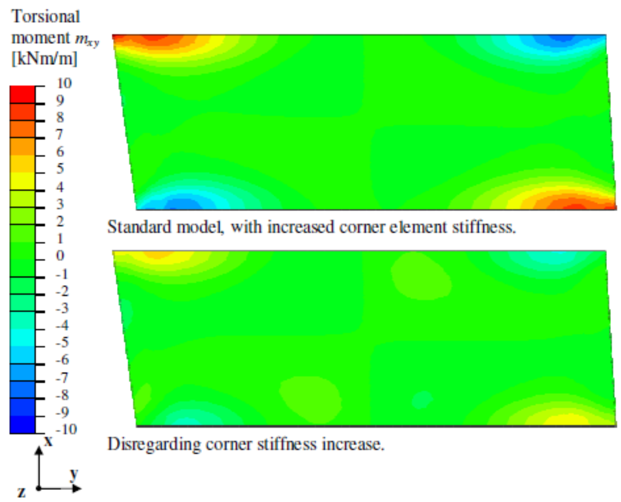

**Primary reinforcement moment envelopes in section 1-1, in the middle of the bridge deck. Negative moment is resisted by top reinforcement and positive moment is resisted by bottom reinforcement.**




**Primary reinforcement moment in section 3-3, along the midspan of the bridge deck.**



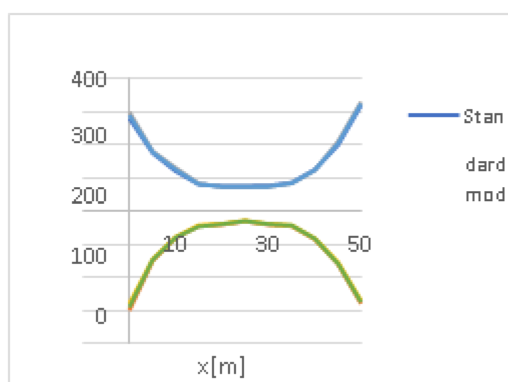

**Primary reinforcement moment in section 2-2, see Figure 6.5, near the edge beam of the bridge deck.**




**Difference in torsional moment in the bridge deck for load case self-weight. The model neglecting support stiffness (bottom) shows substantially lower torsional moment near the deck corners than the models accounting for support stiffness (top).**

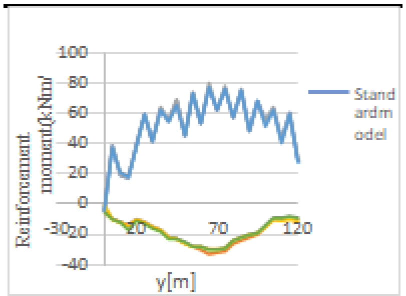
**Secondary reinforcement moment in the bridge deck**

In the optional support second bearing there was no way to see a contrasts between any of the models, see Figure 6.12, with the exception of close to the bridge decks corners where twist second had a huge impact, see Figure 6.11.




**Secondary reinforcement in section 1-1, a section between the frame walls in the mid of the bridge deck.**

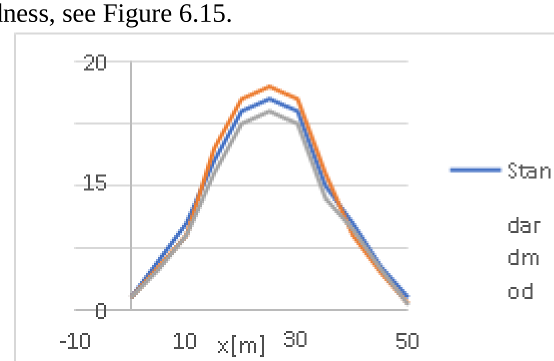
A fascinating demonstrating impact introduced in all models



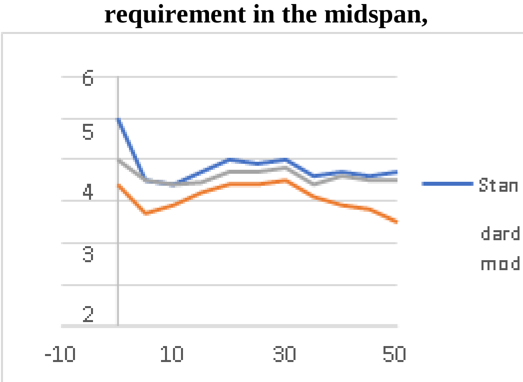

**Secondary reinforcement moment in section 3-3. Notice the variation of moment in the maximum envelope (lower curves).**

**Required reinforcement amount in the bridge deck** Required support for the bridge deck was determined by area 5.3. By ascertaining and looking at support sums the deck cross segment and related sectional powers was represented, further outlining the effect of demonstrating methodology.

The distinction in second conveyance introduced in area brought about an interest for more essential base support in the model dismissing corner firmness, see Figure 6.14, and more top support in the models representing the corner solidness, see Figure 6.15.

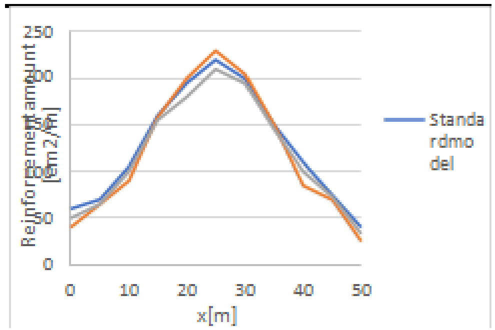



**Required primary bottom reinforcement in section 1-1. Model neglecting corner stiffness showed higher requirement in the midspan,**




**Required primary top reinforcement in section 1-1. Model neglecting corner stiffness showed higher requirement in the midspan**

By studying the sum of top and bottom primary reinforcement requirement it could be seen that the differences between the models indeed only resulted in a different reinforcement distribution in the deck, see Figure 6.16. is the variety of greatest wrap optional second in the midspan segment 3-3, see Figure 6.13. This is an impact of traffic stacking in discrete stacking lines, see Figure 6.3, in a plan situation this ought to be streamlined utilizing the pinnacle esteems to represent the stacking applied anyplace on the deck.




**Total required primary reinforcement in section 1-1. Only very small differences can be seen between the different models.**

## V. CONCLUSION

- In this proposal distinctive demonstrating techniques for underlying examination in plan of concrete bridges are considered. The outcomes show that as a rule there are just little contrasts between the models and strategies for primary examination. Nonetheless, it was distinguished that when demonstrating as indicated by certain standards accidental restriction may be acquainted with the model if certain consideration was not taken. This may adjust the reaction radically, while still be hard to distinguish when concentrating on envelopes in ULS.
- Presentation of unintentional limitation was for the most part an issue when demonstrating with solid shell components in outline corners. It was distinguished that absence of check and hardships in deciphering results could without much of a stretch lead to botches and undesired outcomes.
- It was additionally seen that some load models give contrasts in outcomes. However it was not concentrated exhaustively, it very well may be seen that various strategies for displaying outline divider and soil connection gave distinctive second circulations over the edge dividers. The load model for earth pressure increment introduced in Trafikverkets suggestions report, Trafikverket (2009b), was more troublesome and less instinctive to use in 3D examinations.

- Overall one might say that confirmation and understanding of 3D models can be troublesome. It is likewise hard to survey the conduct of a 3D model under specific kinds of stacking in advance, for instance temperature load impacts. Subsequently cautiously and basically concentrate on the outcomes to evaluate their validity. Since demonstrating in 3D is on a basic level a prerequisite for primary examination today, there is a requirement for rules and simple to utilize confirmation strategies.
- The reaction of concrete constructions is in actuality non-direct, while the plan of such a design is made based on a straight primary examination. This is conceivable because of the designs capacity to adjust, gave limits by rearrangement of sectional powers to stiffer districts in the construction. As the reason for a primary examination for configuration isn't to precisely depict the reaction of the design, different boundaries for the underlying investigation model ought to be focused less difficult models, since mistakes in any case effectively emerge in 3D displaying.

## REFERENCES

[1] Al-Emrani, M., Engström, B., Johansson, M. & Johansson, P. (2008): Bärande konstruktioner Del 1 (Load bearing structures part 1. In Swedish). Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg.

[2] Blaauwendraad, J. (2010) Plates and FEM - Surprises and Pitfalls. Springer, Dordrecht.

[3] Broo, H., Lundgren, K. & Plos, M. (2008): A guide to non-linear finite element modelling of shear and torsion in concrete bridges. Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg.

[4] Caselunghe, A. & Eriksson, J. (2012): Structural Element Approaches for Soil- Structure Interaction. MSc. Thesis. Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg.

[5] Dassault Systèmes (2008) Abaqus User's Manual. Dassault Systèmes, United States of America.

[6] Davidson, M. (2003): Strukturanalys av brokonstruktioner med finita elementmetoden - Fördelning av krafter och moment (Structural analysis of bridge structures with the finite element method - Distribution of forces and moments. In Swedish). Brosamverkan Väst, Göteborg.

[7] Engström, B. (2011a): Design and analysis of continuous beams and columns, Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg.

[8] Engström, B., (2011b). Design and analysis of deep beams, plates and other discontinuity regions. Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg.

[9] Fib Bulletin 45 (2008): Practitioner's Guide to Finite Element Modelling of Reinforced Concrete Structures. CEB-FIB, Lausanne.

[10] O'Brien, J. E. & Keogh, L. D. (1999): Bridge deck analysis. E & FN Spon, Cornwall.

[11] Plos, M. (1996): Finite element analyses of reinforced concrete structures. Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg.

[12] Rombach, G. A. (2004): Finite element design of concrete structures. Thomas Telford, Cornwall.

[13] Scanscot Technology AB (2010): Brigade/Plus User's Manual. Scanscot Technology AB, Sweden.

[14] SS-EN 1991-2 (2007). Eurokod 1: Laster på bärverk - Del 2: Trafiklast på broar (Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges. In Swedish). SIS Förlag AB, Stockholm.

[15] SS-EN 1992-1-1, 2008. Eurokod 2: Dimensionering av betongkonstruktioner - Del 1- 1: Allmänna regler och regler för byggnader (Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings. In Swedish). SIS Förlag AB, Stockholm.