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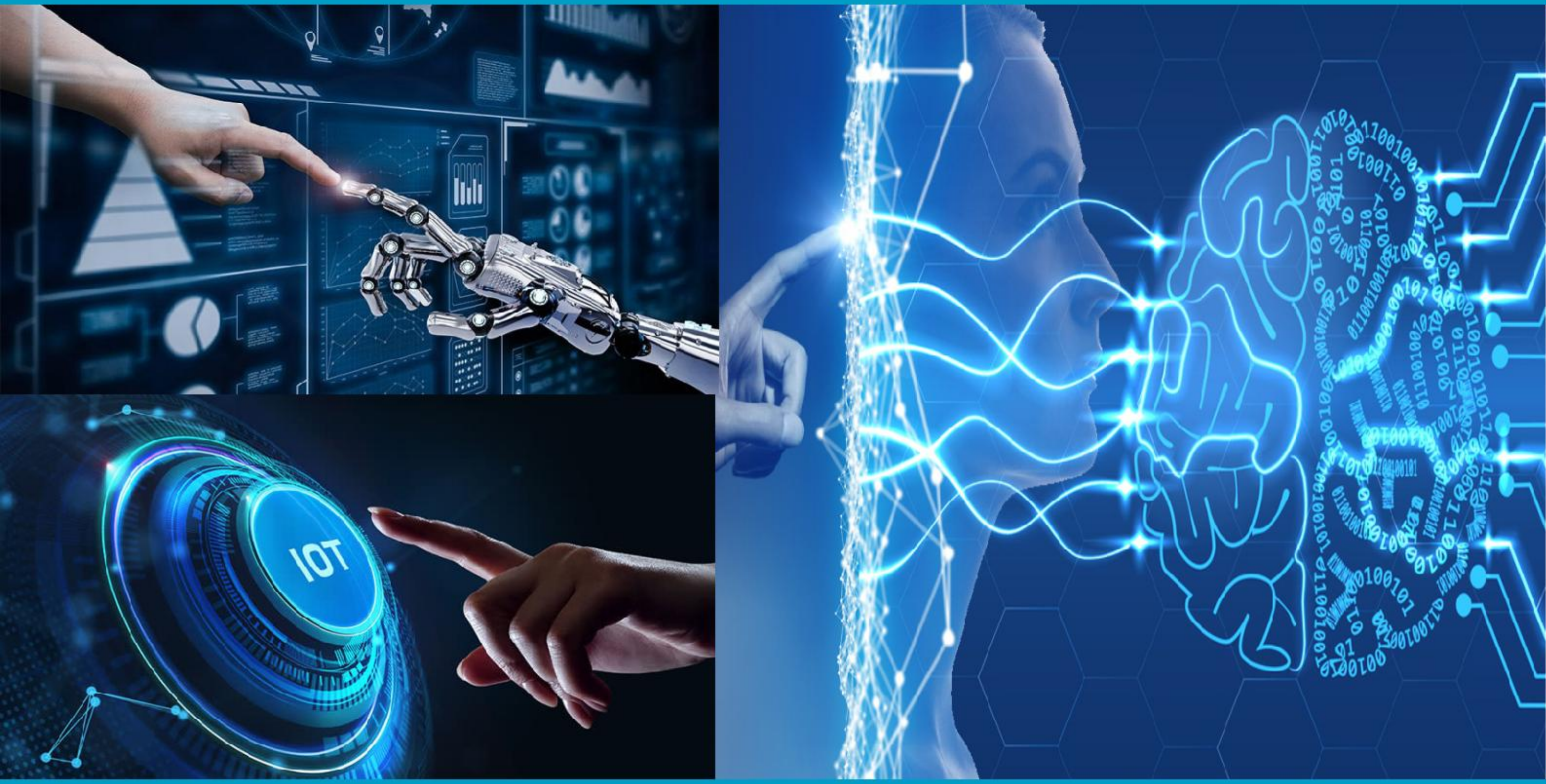

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RCC Box Culverts Outperformed other culverts such Pipe Minor Bridge Slab Culverts though 3D Analytical Model Modelling (STAAD PRO.)

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ABSTRACT: An investigation of the design of a concrete RCC Box is conducted in this thesis. Results reveal that in most situations, models and manual approaches for structural analysis are indistinguishable. If care is not taken while modelling according to certain concepts, unintentional constraints may end up being included. This might have a significant impact on the reaction, but it's tough to tell whether one looking at ULS or SLS envelopes. Modeling using rigid shell parts at frame corners produced unintended constraint most often. It was determined that errors and undesirable outcomes might be readily caused by a lack of verification and difficulty in comprehending data. A model's accuracy doesn't matter as much as if it doesn't introduce any mistakes, since the differences between models are so minor. For the sake of simplicity, we may claim that avoiding mistakes is more essential than modelling precisely. In order to avoid mistakes in 3D modelling, an analytical model should be readily tested with smaller models. It is important to note that these recommendations only apply to building constructions; when analyzing the reaction of existing structures, alternatives are required. Culverts were fixed using STAAD PRO. Manual solutions and commercially available software (STAAD PRO) were compared to see how they fared. As a precautionary measure against foundation collapse and to keep excessive settlement and differential settlement at bay, it is essential that the net maximum bearing pressure beneath the structure's foundation be compared to the safe maximum ground pressure. Overheating of the visible soil connector or excessive soil fluctuations may result in the collapse of the entire structure. Before making a final design for a building, two conditions must be considered to determine whether the proposed geometry and the structural design are appropriate or not. Critical loading conditions are assessed, and Limit State concepts are used for the construction of building and foundation components. The end-to-end condition and the performance-level condition are checked.

KEYWORDS: concrete RCC Box, STAAD PRO, 3D analytical model, pipe minor bridge slab culverts

I. INTRODUCTION

In situations when a drain or channel has to cross a road but has a low discharge and limited bearing capacity, box culverts are employed. Where the discharge hole is smaller than 15m2 and the road crosses the canal at a moderately high embankment, culverts are always less expensive than bridges. Reinforced concrete box culverts are available in precast or cast-in-place varieties. In most cases, the proportions are square, but if they aren't, the span length frequently exceeds the height of the entrance. Depending on the design, a box culvert may have a single cell entrance or many. They regulate irrigation and municipal water flow and drainage, storm water management, and a slew of other tasks. Researchers in culvert design and construction are encouraged by the reasons outlined above.

The design of India and many other developing countries is based on the standard design of advanced nations. It is possible that the conventional plans for concrete box culverts in India are inappropriate due to the country's varying climate and soil conditions. Standard drawings for different types of loading & grades of concrete, reinforcement grade of concrete box culverts in India can be deduced by using this STAAD PRO.

II. STRUCTURAL ANALYSIS OF RCC BOX CULVERT

Reinforced concrete box culverts are often limited in span to 5 meters; however, this is not a hard and fast rule. When a road is embankment, it is possible that the box's top will be lower than the road level. Because of the increased

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thickness of the slab and walls, a single box culvert becomes uneconomical if the planned discharge is substantial. Multiple boxes may be cast side by side in a single mound. Figure1 shows a typical view of a box culvert.

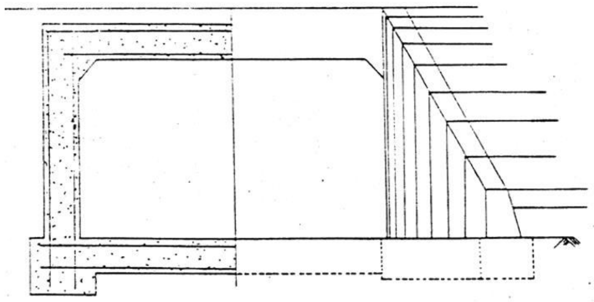

Fig. 1 Box Culvert - half section and half elevation.

ANALYSIS & DESIGN METHOD

When designing box culverts, end bases are tested and considered as solid frames with equal bending times. The end times in private joints are usually calculated using a temporary distribution method.

Structural members and the foundation are designed using Limit State concepts in accordance with critical loading conditions. Consideration is given to both serviceability and ultimate limits.

Modeling

Figure 2 shows the 3D shell components used to build the bridge, described in accordance with the analysis formula using the "STAAD PRO" tool, with a diameter of 300mm on the top slab, 350mm on the bottom slab, and 300mm on the outer wall.

According to the general rule of thumb, the size of the element should not exceed the thickness. The model was based on unbroken concrete sections as the investigation focused on the features of the expandable material. Concrete with a modulus of 30 GPa stretch, 0.2 poisoning ratio, and a thermal expansion coefficient of 10-5 as selected.

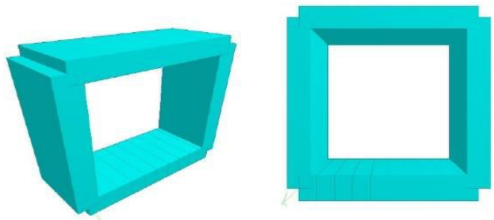

Fig. 23D shell components

EFFECTIVE WIDTH METHOD

It is believed that a moving live load would change the culvert's effective width (length across span). In the design of culverts, this breadth has a considerable impact on the consideration of live loads.

$bef = \alpha e (1 - a / L0) + b1$

bef = The effective width of the slab where the load is applied.

L0 = Active time.

a = The distance between the gravitational force of the fixed load from the nearest Support.

B1 = Width of the concentration area of the load.

α = Staying has the following values depending on the ratio b / L0.

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III. DESIGN OF BOX CULVERT

Concrete box culverts are the focus of this investigation. First, the bending times for each meter of culvert were analyzed using assumptions that the walls and roof were of a certain thickness. In order to calculate the bending moments, we considered the culvert to be a rigid frame or a continuous beam with equal bending moments at each of its four spans. In order to determine the probable loads and pressures, bending moments were computed. In most cases, there are three things to keep in mind:

❖ Culvert is free: full load and additional charges on high slab, wall weight, high ground pressure and live load charge on walls.

❖ Durability: Minimum grade of concrete shall be M30 for sever environmental exposure condition.

❖ Cover to any reinforcement shall not be less than 40mm

4.9 SUMMARY OF FACTORED MOMENT AND SHEAR

Load Case	Top slab			Bottom slab			Outer wall				
	Moment in Mid-Span	Moment at End Support	Top slab shear at deff	Moment in Mid-Span	Moment at End Support	Bottom slab shear at deff	Min. Axial force	Moment at top	Moment at bottom	Span Moment	Wall shear at deff
		at face			at face			at face	at face	Earth Face	
	kN-m	kN-m	kN	kN-m	kN-m	kN	KN	kN-m	kN-m	kN-m	
*Partial Safety for Verification of Structural Strength (Basic Combination)	-57.5	27.6	104.2	-	-	-	0.0	40.4	40.4	1.0	61.7
*Partial Safety for Verification of Serviceability Limit State (Rare Combination)	-42.6	19.0	-	53.1	-19.9	-	-	28.8	27.4	3.1	-
*Partial Safety for Verification of Serviceability Limit State (Quasi-permanent Combination)	-33.4	17.5		42.2	-16.6	-	-	25.4	24.0	-1.5	-
*Dry Combination for Design of Foundation (Combination 1)	-	-	-	71.2	-19.7	90.2	-	-	-		-

IV. RESULT AND DISCUSSIONS

Concrete box culvert difficulties may be solved using STAAD PRO software. In the application process, one kind of culvert was evaluated so that the STAAD PRO software could be adapted to various types of box culverts. We verified our STAAD PRO output with results from a manual solution and results from commercially available software to ensure our calculations were accurate. The STAAD PRO program's findings were compared against the outcomes of previously solved issues in order to verify the program's correctness. A structure's limit state of collapse refers to the strength and stability of a structure when it is exposed to the most extreme combinations of design loads. So, this limit state makes sure that no component of the structure or the whole thing will fall apart or become unstable when subjected to a variety of predicted overloads.

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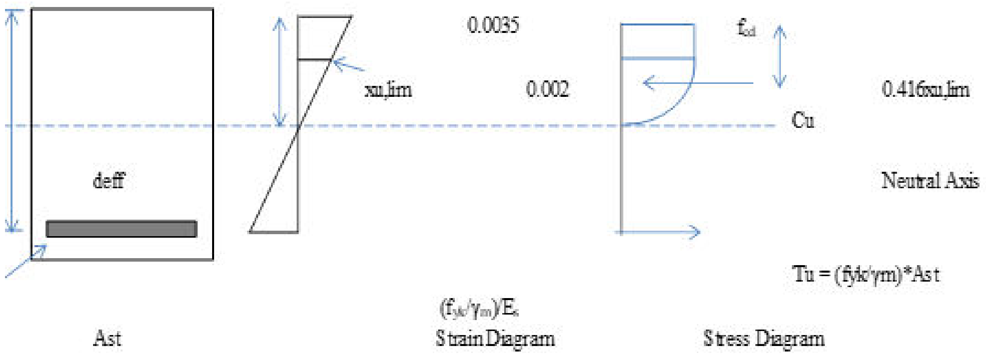
Verification of structuralstrength top slab



ULTIMATE LIMIT STATE

Grade of Concrete f_{ck} = 30 N/mm^2

As per clause 6.4.2.8, IRC:112-2011

f_{cd}	=	13.40	N/mm^2	For Basic Combination
f_{cd}	=	16.75	N/mm^2	For Accidental Combination
f_{cd}	=	13.40	N/mm^2	For Seismic Combination

E_c = 31000 MPa

Grade of steel	f_y	=	500	N/mm^2	
	f_{yd}	=	435	N/mm^2	For Basic Combination
	f_{yd}	=	500	N/mm^2	For Accidental Combination
	f_{yd}	=	435	N/mm^2	For Seismic Combination

Refer Fig. 6.2 of IRC:112-2011

For steel reinforcement, simplified bilinear diagram is used

Minimum strain in steel reinforcement = 0.87 fy / Es

Es = 2.0E+05 MPa E_c = 31000 MPa

Cu = $fcd*b*(3/7xu_{,lim} + 2/3*4/7xu_{,lim})$

= 17/21*fcd*b*xu

= 0.8095 *fcd*b*xu

Refer Chaper 5 of Reinfroced Concrete Limit State Design by Ashok K. Jain

cg of compression block from top = 0.416 xu

Tu = fyd*Ast

$R_{lim} = M_{u,Lim}/bd^2$ = $0.8095fcd*(xu_{lim}/d)*(1-0.416*xu_{lim}/d)$

	Basic Comb	Accidental Comb	Seismic Comb
$xu_{,lim}/d$	0.62	0.58	0.62
$R_{lim} = M_{u,Lim}/bd^2$	4.97	5.99	4.97

Here R_{lim} is in MPa

Calculation of Reinforcement

Width of section b = 1000 mm

Depth of section D = 300 mm

Clear cover = 40

Diagram: SIDL +EC: BM

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Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Basic Comb			Basic Comb		
Actual moment (KNm)	27.6			57.5		
b	1000			1000		
D	300			300		
c	40			40		
d	255.0			246.0		
f_{cd}	13.40			13.40		
f_{Yd}	435			435		
xu_{lim}/d	0.62			0.62		
$R_{sls} = M_{u,sls}/bd^2$	4.97			4.97		
$M_{u,Lim}$ (KNm)	323			301		
	OK			**OK**		
Ast Req.	**253**			**559**		
Dia of bar (main tension) (mm)	***10***			***12***		
Spacing (mm)	***200***			***100***		
+ dia of bar (main tension) (mm)	***10***			***0***		
Spacing (mm)	***200***			***200***		
Ast provided (sq mm)	**785**			**1131**		
% Steel	0.31			0.44		
Dia of bar (main compresion) (mm)	0			10		
Spacing (mm)	200			200		
Area of main compresion (mm^2)	0			393		
f_{ctm}	2.5			2.5		
f_{yk}	500			500		
cl. 16.6.1 (2) of IRC :112-2011						
$A_{S,min} = 0.26\, f_{ctm}\, b_t\, d / f_{yk} >= 0.0013\, b_t\, d$	332			320		
A_{ct}	268520			254668		
$f_{ct,eff}$	2.9			2.9		
$k_c = 0.4 \{ 1 - s_c / (k_1\, f_{ct,eff}\, h/h^*) \} <= 1$	0.4			0.4		
For Bending or bending combined with axial force						
k	1.0000			1.0000		
s_s	500			500		
cl. 12.3.6 (4) of IRC :112-2011						
$A_{S,min} = k_c\, k\, f_{ct,eff}\, A_{ct} / s_s$	623			591		
	OK			**OK**		
As.max = 0.025 Ac (main tension)	7500			7500		
cl. 16.5.1.1 (2) of IRC :112-2011	**OK**			**OK**		
As.max = 0.04 Ac (tension + compresion)	12000			12000		
x (mm)	31			45		
x/d	0.123			0.184		
	OK			**OK**		
z (mm)	242			227		
MR (KNm)	**83**			**112**		
	OK			**OK**		
Calculation of Transverse Steel as per Clause 16.6.1.1						
$A_{ST,min}$ = 20% of main reinforcement	124.6			118.2		
Dia of bar (Horizontal Bar) (mm)	**10**			**10**		
Spacing (mm)	**250**			**250**		
Area of distribution bar (mm^2)	314.2			314.2		
	OK			**OK**		

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Moment on the section	Top slab Top End support			Top slab Bottom Mid Span		
	Rare Comb		Quasi-Perma. Comb	Rare Comb		Quasi-Perma. Comb
Actual moment (KNm)	19.0		17.5	42.587		33.4
b	1000		1000	1000		1000
D	300		300	300		300
c	40		40	40		40
d	247.0		247.0	246.0		246.0
f_{cd}	14.40		10.80	14.40		10.80
f_{Yd}	400		400	400		400
xu,sls/d	0.64		0.64	0.64		0.64
$R_{sls} = M_{u,sls}/bd^2$	5.45		4.09	5.45		4.09
$M_{u,sls}$ (KNm)	333		250	330		248
	OK		**OK**	**OK**		**OK**
Ast Req.	194		179	444		349
Dia of bar (main tension) (mm)	*10*		*10*	*12*		*12*
Spacing (mm)	*200*		*200*	*100*		*100*
+ dia of bar (main tension) (mm)	*10*		*10*	*0*		*0*
Spacing (mm)	*200*		*200*	*200*		*200*
Ast provided (sq mm)	785		785	1131		1131
Dia of bar (main compresion) (mm)	0		0	10		10
Spacing (mm)	200		200	200		200
Area of main compresion (mm^2)	0		0	393		393
f_{ctm}	2.5		2.5	2.5		2.5
x (mm)	27.0		35.9	38.8		51.7
x/d	0.109		0.145	0.158		0.210
	OK		**OK**	**OK**		**OK**
z (mm)	236		232	230		224
MR_{sls} (KNm)	74		73	104		102
	OK		**OK**	**OK**		**OK**
$s_{sc} = M/(A_s z)$	103		96	164		132
	OK		**OK**	**OK**		**OK**
$s_{ca} = M/(0.8095\, z\, b\, x_u)$	3.69		2.59	5.90		3.55
	OK		**OK**	**OK**		**OK**

V. SUMMARY AND CONCLUSIONS

An investigation of the design of a concrete RCC Box is conducted in this thesis. Results reveal that in most situations, models and manual approaches for structural analysis are indistinguishable. If care is not taken while modelling according to certain concepts, unintentional constraints may end up being included. This might have a significant impact on the reaction, but it's tough to tell whether you're looking at ULS or SLS envelopes. Modeling using rigid

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shell parts at frame corners produced unintended constraint most often. It was determined that errors and undesirable outcomes might be readily caused by a lack of verification and difficulty in comprehending data.

It is possible for a building engineer to be flexible in developing model analysis models as the impact of model development decisions is generally small, as long as errors are avoided. A model's accuracy doesn't matter as much as if it doesn't introduce any mistakes, since the differences between models are so minor. For the sake of simplicity, we may claim that avoiding mistakes is more essential than modelling precisely. In order to avoid mistakes in 3D modelling, an analytical model should be readily tested with smaller models.

It is important to note that these recommendations only apply to building constructions; when analyzing the reaction of existing structures, alternatives are required.

Culverts were fixed using STAAD PRO. Manual solutions and commercially available software (STAAD PRO) were compared to see how they fared.

As a precautionary measure against foundation collapse and to keep excessive settlement and differential settlement at bay, it is essential that the net maximum bearing pressure beneath the structure's foundation be compared to the safe maximum ground pressure.

Overheating of the visible soil connector or excessive soil fluctuations may result in the collapse of the entire structure. Before making a final design for a building, two conditions must be considered to determine whether the proposed geometry and the structural design are appropriate or not.

Critical loading conditions are assessed, and Limit State concepts are used for the construction of building and foundation components. The end-to-end condition and the performance-level condition are checked.

VI. CONCLUSIONS

Stead ORO software was used to examine the RCC box culvert's limit state performance under both ultimate and serviceability limit state techniques. This study's key finding is that RCC box culverts outperformed other culverts such pipe minor bridge slab culverts, etc. when it came to constructing roads. In any case, the following are some of the particular findings of this research: Box culvert is used for cross drainage works across high embankments.

- ❖ It is easy to increase the length in the event of an extension of the road using STAAD PRO.
- ❖ The design of the box culvert is covered using three loading cases. Prices for design times etc.
- ❖ Studies show that the best moment grows in the middle of the upper and lower slab in the case of hogging in the middle and support the collapsing moment to grow the sides of the collar that do not carry a live load and the culvert is full of water.
- ❖ Negative upper bouts featured two cutaways, for easier access to the higher frets.
- ❖ The negative maximum time increases between the vertical wall area where the culvert is fully operational and when the pressure on the same side due to the heavier set load only works.
- ❖ Large shear forces grow in the corner of the upper and lower slab where the culvert is full and the upper slab carries the dead and the living load.

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Item	LSM 112:2011	IRC 21:200
Top Slab	12@100 c/c	12@120 c/c
Bottom Slab	12@100 c/c	12@130 c/c
Side Wall	10@200 c/c	10@220 c/c
Design Base Pressure	14.3 t/m2	10.17 t/m2
SIZE		
Top	300mm	280 mm
Bottom	350 mm	350 mm
Side Wall	300 mm	280 mm

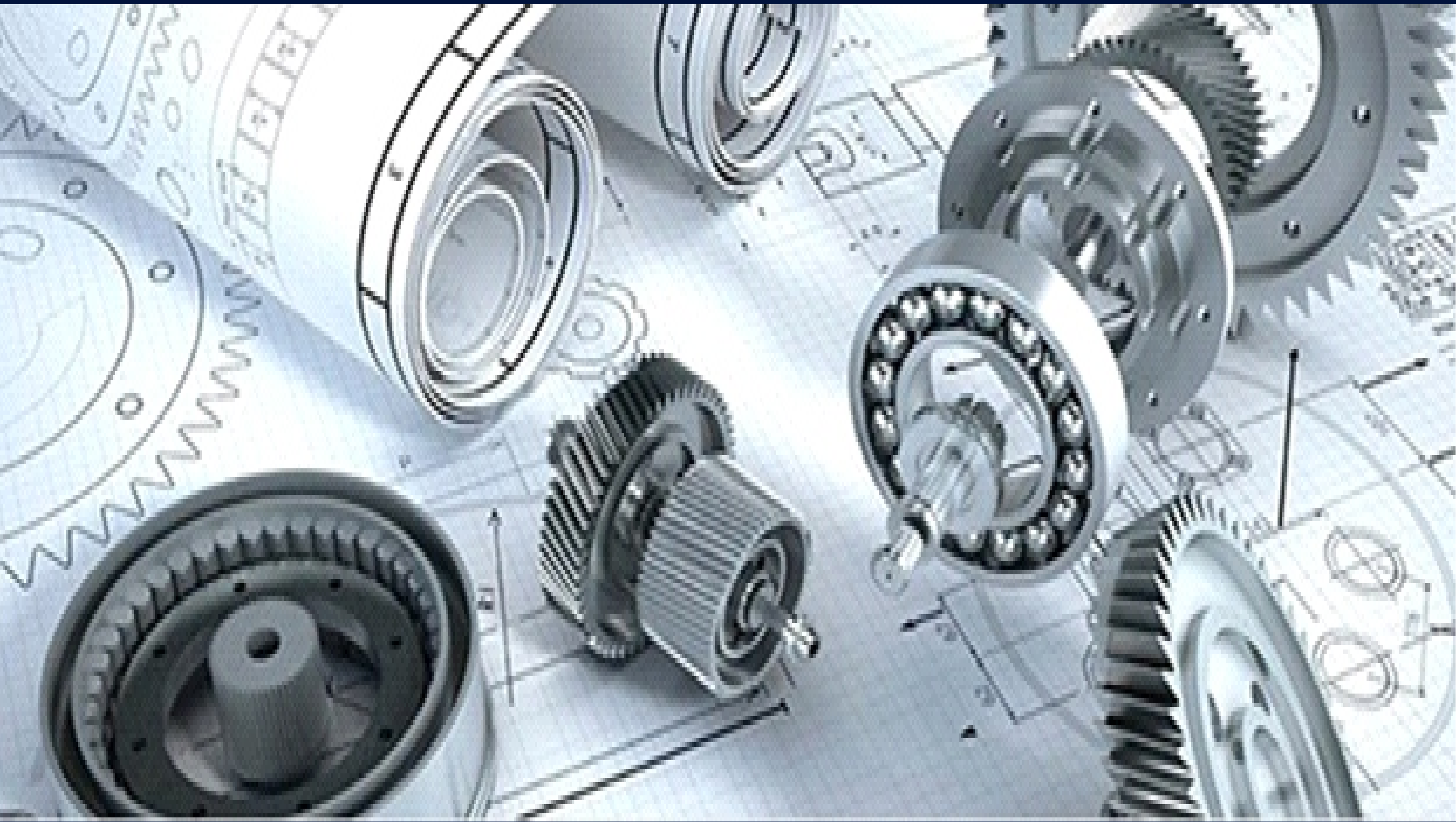
Limitation and future scope

Though care and attention have been devoted to many technical difficulties, the product is not technically sound or complete. However, the STAAD PRO and effective width approach, as well as the one used in the current research, both have their drawbacks. Shear forces are not included in the effective width technique per IRC 112:2011. Shear force diagrams are not depicted in the above chapter since they are not required for a shear check as mandated by the code, although bending diaphragms are. stiffness and strength to distribute stresses to all resistant parts Side components are connected to the rest of the wall in a variety of ways. Inelastic deformations were ignored in favor of an elastic method for assessing torsion effects. Some limitations are given bellow

- Survival and appearance Shrinkage
- Due to vertical and horizontal loads, there will be an increase in the pressure on the ground.
- Surcharge
- Top slab should have a uniform temperature change and a gradual temperature gradient.
- This includes lateral and horizontal loading caused by acceleration and braking in accordance with IRC 6:2017.
- Load combinations for ULS are also included in the studies.
- Load combinations included in the analyses include load combination for SLS

REFERENCES

1. Reinforced concrete structure; volume:2; DR.B.C. PUNIMA, ASHOK.K. JAIN, ARUN.K. JAIN.
2. Design of bridge structure; T.R. JAGADEESH, M.A. JAYARAM
3. IRC: 6-2017, "Standard Specifications and Code of Practice for Road Bridges", Section II
4. IRC: 5-195, "Standard Specifications and Code of Practice for Road Bridges",
5. SINHA & SHARMA ON Journal of the Indian Roads Congress, October-December 2009.
6. Y. Vinod Kumar, Dr. Chava Srinivas IJESR/ July 2015/ vol-5/ issue-7/850-861 international journal of engineering & science research.
7. IRC: 112-2011, "Code of Practice for Concrete Road Bridges"
8. IRC 105 : 2015 Explanatory-handbook-to-irc-112-2011
9. Concrete road bridges structure; V.K.Raina
10. IRC-78-2000 Foundation and substructure
11. STANDARD PLANS FOR HIGHWAY BOX
12. IRC:SP : 13 :2000 Guideline for small bridges and culverts



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