ISSN : 2455-9679
Impact Factor : 2.015

IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

"DESIGN COMPARISION OF RIGID PAVEMENT BY IRC:58-2002 AND IRC:58-2011"

***Sanjay Patidar* [1] *, Shashikant B. Dhobale* [2]**

[1] *PG Scholar, Civil Engineering Dept., JIT, Borawan, (M.P.), India*

[2] *Assistant Professor, Civil Engineering Dept., JIT, Borawan, (M.P.), India*

ABSTRACT

The design and construction of the roadbed for any pavement structure is key to its longterm performance and smoothness over time. A variety of engineered subbase materials and subgrade treatment methods exist for use with concrete pavement. Careful attention to the design and construction of sub grades and subbases is essential to ensure the structural capacity, stability, uniformity, durability, and smoothness of any concrete pavement over the life of that pavement. The analysis done with the help of IRC: 58- 2011 is verified with the previous guidelines (IRC: 58-2002 [2]) according to which, "if the cumulative fatigue damage caused by the single and tandem axle loads is less than one and if the sum of temperature and flexural stresses due to the higher wheel load is less than the modulus of rupture, then the thickness is said to be safe". The results of the analysis are totally different from the analysis done using IRC: 58-2011 and these are represented in graphical form. Figure for IRC 58-2002 which shows the safe thickness, granular subbase (GSB) of 150 mm thickness. It can be clearly seen that with the increase in the subgrade strength, design thickness is decreasing.

KEYWORDS: *Pavement structure, Concrete structure, IRC 58-2002, IRC 58-2011, Granular subbase.*

I. INTRODUCTION

The factors governing design of cement concrete pavement have been discussed below: i) Wheel Load: Heavy vehicles are not expected on rural roads. The maximum legal load limit on single axle with dual wheels in India being 100KN, the recommended design load on dual wheels is 50 KN having a spacing of the wheels as 310 mm centre to centre. ii) Tyre Pressure: For a truck carrying a dual wheel load of 50 KN the tyre pressure may be taken as 0.80 MPa and for a wheel of tractor trailer, the tyre pressure may be taken as 0.50 MPa. iii) Design Period: The design period is generally taken 20 years for cement concrete pavement. iv) Characteristics of the Sub-grade: The strength of sub-grade is expressed in terms of modulus of sub-grade reaction (k). Since, the sub-grade strength is affected by the moisture content, it is desirable to determine it soon after the monsoons. v) Sub-base: A good quality compacted foundation layer provided below a concrete pavement is commonly termed as sub-base. It provides the concrete pavement a uniform & firm support and acts as a leveling course below the pavement. vi)Concrete Strength: Since, concrete pavement fails due to bending stresses, it is necessary that their design is based on the flexural strength of concrete. vii) Modulus of Elasticity (E) and Poisson's Ratio (μ): The Modulus of Elasticity of concrete and Poisson‟s ratio may be taken as 30,000 MPa and 0.15 respectively. vii) Co-efficient of Thermal expansion (α) The co-efficient of thermal expansion of concrete may be taken as 10x10-6 per ^{o}C.

ISSN : 2455-9679
Impact Factor : 2.015

II. LITERATURE SURVEY

Narender Singh, 2015 state that India is an agriculture based country and more than 70 percent of the population is residing in the rural areas. The rural traffic consisting mostly agricultural tractors/trailers, goods vehicles, buses, animal driven vehicles, autorickshaws, motor cycles, bi-cycles, light or medium trucks carrying sugarcane, quarry material etc. The road passing through a village/built-up area usually found damaged due to poor drainage of water. Therefore, flexible pavement in the built-up area is to be substituted with the concrete. pavement to make it durable and to avoid wastage of nation money on repeated treatments. The different aspects of design of concrete pavement should be taken care prior to construction for making the same durable and cost effective. 11 The guidelines contained in IRC: SP: 62-2014 are applicable for low volume roads with average daily traffic less than 450 Commercial Vehicles per Day (CVPD).

Surender Singh, Dr.S.N.Sachdeva state that The main factors affecting the thickness of the cement concrete pavement are subgrade strength axle load repetitions, type of sub-base and shoulders. Well-designed and maintained 19 shoulders are an important part of cement concrete pavement. In this paper a design of a typical two lane divided carriageway is done, which is proposed to be laid in Haryana. The design has been carried out for different subbase such as dry lean concrete of 100 mm thickness, granular subbase of 150 mm thickness and cement treated subbase of 100 mm thickness with tied and untied shoulders and CBR value of 20 subgrade varying from 2% to 10% and then selecting the best possible subgrade soil, subbase material and shoulders that can support the pavement effectively and economically.

III. PROBLEM IDENTIFICATION

Report Collected From Live Project

1. Name of work: Detailed Estimate for Two Lane Paved Shoulder with Rigid Pavement i/c Construction of Bridges & Culvert in Km. 24 to 92 on NH-59A (Indore – Betul Road)

2. Length of work: 69.00 KMS.

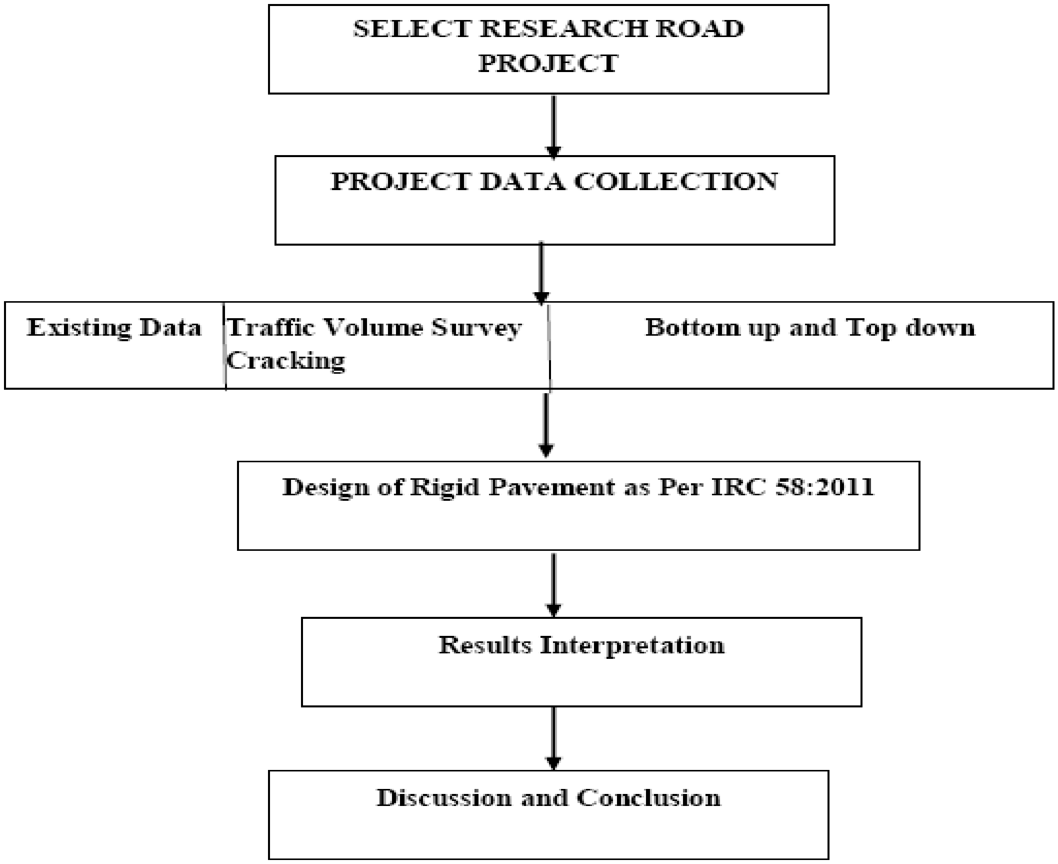
3. History:

• Status of Road before declaration as NH-59A :- This road was known as SH-22 previously named as Indore Khategaon Sandalpur Gopalpur. That was 50 to 60 years old. The road width in proposed km 24 to 41 was 5.00 meter. In km 42 to 92 was 3.00 meter, vide B.T. road before declaration as NH-59A. Indore Betul Road was declared as a National Highway in October 2000 by MORT&H.

• Existing embankment details of NH-59A :- Most of the proposed length in km. 24 to 92 passes through B. C. Soil area. In km. 24 to 41 and km 70 to 92 existing embankment including crust is nearly 50 cm average above ground level.

ISSN : 2455-9679
Impact Factor : 2.015

IV. Methodology



V. Data Collection & Analysis

Existing Crust details of NH-59A :- The crust details from km. 24 to 92 as below :-

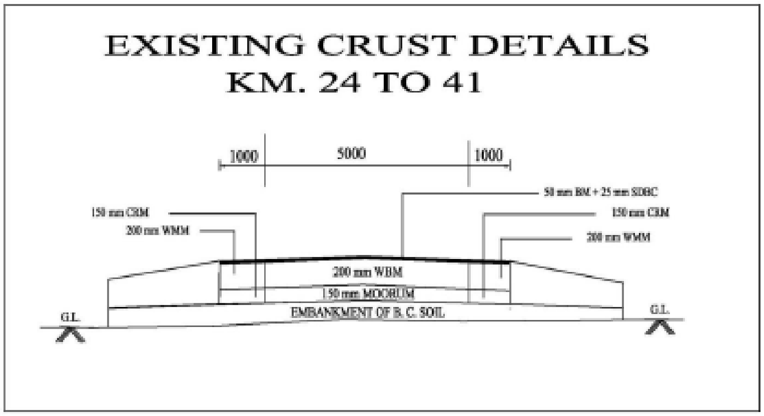


Figure: The crust details from km. 24 to 41

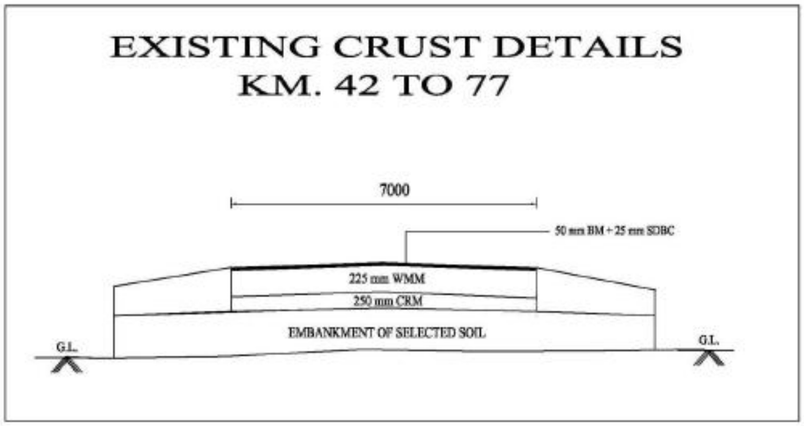


Figure: The crust details from km. 42 to 77

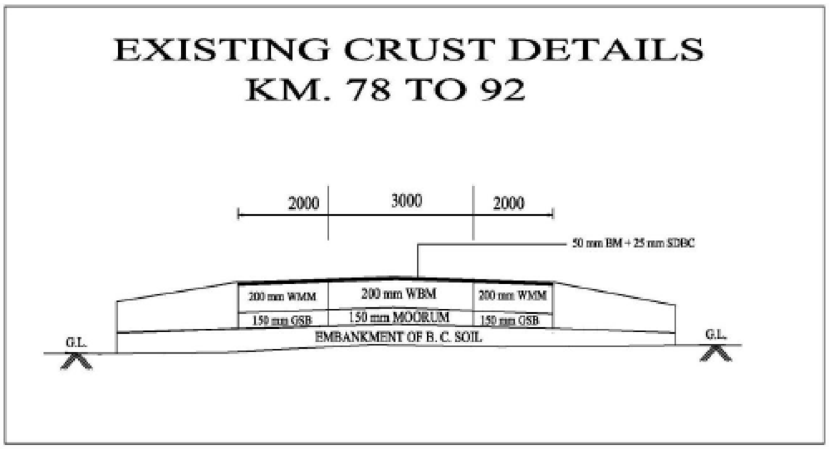


Figure: The crust details from km. 78 to 92

Treatment on existing Road after declaration as NH-59A :- The existing road was widened from single lane to two lane after declaration of NH - 59 A. Details as Under :-

(i) Widening work from km 24 to 41 by State PWD NH in year 2010.
(ii) Widening work From Km. 42 to 77 by NHAI in year 2013.
(iii) Widening work From Km. 78 to 92 by State PWD NH Division in year 2010.

Connectivity of Existing road NH-59A:- Indore Betul Road NH-59 A is very heavy traffic intensity corridor. It connects Indore to Maharashtra also cater traffic from Gujrat and Rajasthan.

Failure Criteria of existing road NH-59A:- A pavement is designed against an assumed design life. After the expiry of the designed period, the pavement is likely to fail structurally, and therefore it would require a major renewal to extend its life further. Top BT surface of the road is always likely to be subjected to considerably various types and forms of pavement distresses during its entire design life, which may occur simultaneously, because many of the distress are interrelated and the occurrence of one may as well initiate the other mainly due to the movement of vehicles thermal variations and climatic effects, which causes various types of defects in the pavement surface. Individual assessment and quantification of distresses may not therefore be very useful, rather there is need to assess the functional condition of the pavements a whole as per the Indian specification for classifying pavement condition.

ISSN : 2455-9679
Impact Factor : 2.015

VI. Design of Rigid Pavements

Table: Axle Load Spectrum

Single Axle		Tandem Axle		Tridem Axle	
Axle Load Class kN	Frequency (% of Single axles)	Axle Load Class kN	Frequency (% of Tandem axles)	Axle Load Class kN	Frequency (% of Tridem axles)
190	2.01	390	18.80	545	0.00
180	0.40	370	17.35	515	0.00
170	2.21	350	24.58	485	0.00
160	16.89	330	13.83	455	0.00
150	10.59	310	4.92	425	20.73
140	23.66	290	4.19	395	19.51
130	17.76	270	0.14	365	21.22
120	11.93	250	5.49	335	18.29
110	6.17	230	5.30	305	18.05
100	0.40	210	0.24	275	0.73
90	0.67	190	4.82	245	0.49
80	7.31	170	0.34	215	0.98

(a) Selection of modules of subgrade reaction:-

1. Effective CBR of compacted subgrade = 8 percent, Modulus of subgrade reaction
= 50.3 Mpa/m,
2. Provide 150 mm thick granuler Sub Base
3. Provide a DLC Sub Base of thickness 100 mm with a minimum 7 day compressive strength of 10 MPa.
4. Effective modulus of Sub Grade reaction of combined foundation of subgrade granular subbase and DLC subbase (from Table 4 by interpolation) = 285 Mpa/m
5. Provide a debonding layer of polythene sheet of 125 micron thickness between DLC and concrete slab.

(b) Selection of Flexural Strength of Concrete

28 - day compressive strength of cement concrete = 40 MPa
90 - day compressive strength of cement concrete = 48 MPa
28 - day Flexural strength of cement concrete = 4.5 MPa
90 - day Flexural strength of cement concrete = 4.5 x 1.1 = 4.95 MP

(c) Selection of Design traffic for Fatigue Analysis :-

Design period = 30 Years
Annual rate of growth of commercial traffic (expressed in decimal) = 0.075
Two way commercial traffic volume per day = 3977 commercial vehicles / day
% of traffic in predominant direction = 50 percent = 1989 CVs in each direction.
Total two-way commercial vehicles during design period.

$$C = \frac{365 \times 3977 \, (1 + 0.075)30 - 1)}{0.075}$$

ISSN : 2455-9679
Impact Factor : 2.015

= 150095090 CVs

Average number of axles (sterring/single/tandem/tridem) per commercial vehicle = 2.35

Total two-way axle load repetitions during the design period

= 150095090 X 2.35 = 352723462 Axle

Number of axles in predominant direction =
352723462 X 0.5 = 176361731

Design traffic after adjusting for lateral placement of axles (25 percent of predominant direction traffic for multi-lane highways).

176361731 X 0.25 = 44090433

Night time (12-hour) design axle repetitions = (60 percent traffic during night time)

= 44090433 X 0.60 = 26454260

Day time (12-hour) design axle repetitions = (1-0.60)

= 44090433 X 0.40 = 17636173

Day time Six-Hour axle load repetitions

= 17636173 X 0.50 = 8818087

Hence design number of axle load repetitions for bottom-up cracking analysis

= 8818087

Night time Six-Hour axle load repetitions

= 26454260 X 0.5 = 13227130

% of commercial vehicles having the spacing between the front (sterring) axle and the first axle of the rear axle unit = 55 percent
Hence, the Six-Hour night-time design axle load repetitions for Top-Down cracking analysis (Wheel base < 4.5 m) =

= 13227130 X 0.55 = **7274922**

The axle load category-wise design axle load repetitions for bottom-up and top-down fatigue cracking analysis are given in following table :-

Table: axle load category-wise design axle load repetitions for bottom-up and top-down fatigue cracking analysis

Axle Category	Proportion of the Axle category	Category-wise axle repetitions for Bottom-up cracking analysis	Category-Wise axle repetitions for top-down cracking analysis
Front (steering) single	0.45	3968139	3273715
Rear Single	0.15	1322713	1091238
Tandem	0.25	2204522	1818731
Tridem	0.15	1322713	1091238

(d) **Cumlative Fatigue Damage** (CFD) analysis for Bottom-up cracking (BUC) and Top-down Cracking (TDC) and selection of Slab Thickness :-

- Effective modulus of subgrade reaction of foundation, k = 39, 63 and 92 for CBR 3%, 10% and 30% respectively.
- Elastic Modulus of concrete, E = 30000 MPa
- Poission's ratio of concrete, μ = 0.15
- Unit weight of concrete, y = 24 kN/m3
- Design flexural strength of concrete = 4.95 MPa
- Max. day-time Temprature Differential in slab (for bottom-up cracking) = 12.5 degree C. (for Madhya Pradesh)
- Night-time Temprature Differential in slab (for top-down cracking) = day-time diff / 2 + 5 = 11.25 degree C.

Pavement Option taken - Concrete pavement with tied concrete shoulder with dowel bars across transverse joints .
Trial Thickness of slab, h = 0.24, 0.26, 0.28, and 0.30 meter (Variable for each sub base)
Radius of relative stiffness, l = (Eh3/(12k(1- μ 2)) 0.25
'I' values are calculated and tabled as follows:

Table: Calculated 'I' values

K = 39 MPa/m at CBR 3%				
h (meter)	0.24	0.26	0.28	0.30
I (meter)	0.97577	1.03614	1.09536	1.15353
K = 63 MPa/m at CBR 10%				
h (meter)	0.24	0.26	0.28	0.30
I (meter)	0.86552	0.91907	0.97160	1.02320
K = 92 MPa/m at CBR 30%				
h (meter)	0.24	0.26	0.28	0.30
I (meter)	0.78735	0.83606	0.88385	0.93079

VII RESULTS

Table: Cumulative Fatigue Damage Values for Four Trial Thicknesses (for Bottom-up Cracking)

Slab Thickness (m)	CFD		
	CBR % / K value		
	3 %/ 39	10% / 63	30% / 92
0.24	62.032	65.621	69.258
0.26	5.921	11.487	6.737
0.28	0.291	0.333	3.103
0.30	0.000	0.000	0.000

Computation of bottom-up and top down cumulative fatigue damage is illustrated in Table 18 and 19. It can be seen from the calculations given in the tables that for the slab thickness of 0.30 m, the total fatigue damage for bottom-up cracking case is 0.000 + 0.000 = 0.000, Total fatigue damage for top-down cracking case = 0.000 + 0.333 = 0.333.

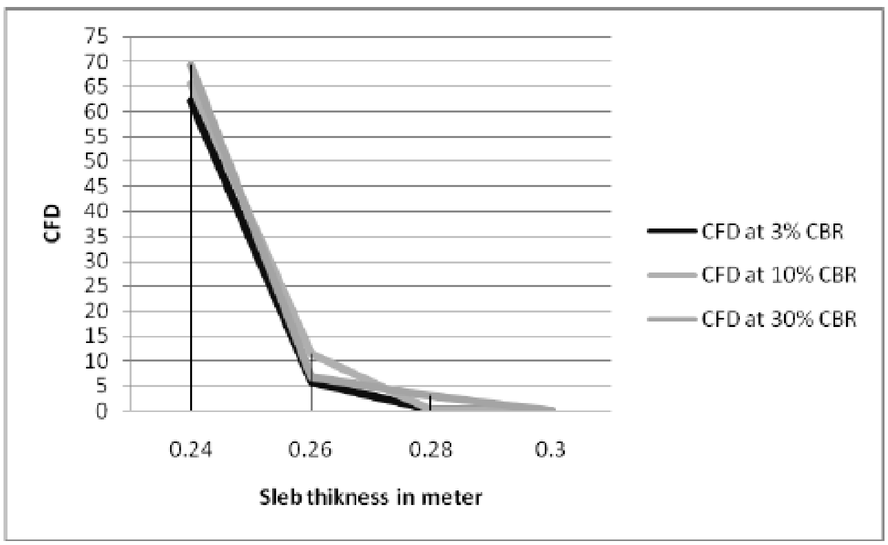


Figure: Cumulative fatigue damage comparison for CBR 3%, 10% and 30%

Result Comparison with IRC: 58-2002

The analysis done with the help of IRC: 58- 2011 is verified with the previous guidelines (IRC: 58-2002 [2]) according to which, "if the cumulative fatigue damage caused by the single and tandem axle loads is less than one and if the sum of temperature and flexural stresses due to the higher wheel load is less than the modulus of rupture, then the thickness is said to be safe". The results of the analysis are totally different from the analysis done using IRC: 58-2011 and these are represented in graphical form. Figure for IRC 58-2002 which shows the safe thickness, granular subbase (GSB) of 150 mm thickness. It can be clearly seen that with the increase in the subgrade strength, design thickness is decreasing.

ISSN : 2455-9679
Impact Factor : 2.015

VIII. DISCUSSION AND CONCLUSION

It is observed from three graphs generated with IRC: 58-2011 that the required safe thickness remains same for all changes in subgrade strength. Moreover, change in the type of subbase material also has no effect on the slab thickness i.e required thickness remains 30 cm. If the same is designed by IRC: 58-2002, the results are obtained as given in figure for IRC: 58-2002. It can be seen from the figure that stronger subgrade leads to lesser pavement thickness.

There is a general perception that stronger the subgrade lesser would be the thickness required for the pavement or conversely weaker the subgrade more is the thickness of cement concrete pavement required. Many a time, the existing soil is either replaced with soil having a higher California bearing ratio or stabilized to enhance the CBR value of using it in the subgrade. There is a general trend that with an increase in the slab thickness, stresses tended to decrease, but according to IRC: 58-2011, "if there is zero temperature differentials, the flexural stresses decrease with increase in effective modulus of subgrade reaction (k-value) for all the thicknesses. But for almost all the positive temperature differential, the warping stresses are high for thicker slabs and it results in higher flexural stresses in slabs while flexural stresses are lower for higher values for thinner slabs.

Validation of the results by previous IRC guidelines shows completely different results with increases in subgrade strength, design thickness decreases, therefore, it is recommended to verify the results by IRC: 58-2002, before placing the design into the actual field.

In future one can also calculate and find the cumulative fatigue damage for various CBR % or K value for top-down cracking.

REFERENCES

[1] IRC: SP: 20-2002, "Rural Road Manual".

[2] IRC: SP: 42-1994, "Guidelines of Road Drainage".

[3] IRC: SP: 62-2014, "Guidelines for Design and Construction of Cement Concrete Pavement for Low Volume Roads (First Revision)".

[4] Dr. R. Kumar, Scientist, Rigid Pavements Division, CRRI, "Design and Construction of Rigid Pavements/Cement Concrete Roads (ppt)".

[5] Pandey, B.B., "Warping Stresses in Concrete Pavements- A Re-Examination", HRB No. 73, 2005, Indian Roads Congress, 49-58.

[6] Westergaard, H. M. (1948), "New Formulas for Stresses in Concrete Pavements of Airfield", ASCE Transactions, vol. 113, 425- 444.

[7] Srinivas, T., Suresh, K. and Pandey, B.B., "Wheel Load and Temperature Stresses in Concrete Pavement", Highway Research Bulletin No. 77, 2007, 11-24.

[8] Bradbury, R. D. (1938), "Reinforced Concrete Pavements", Wire Reinforcement Inst., Washington, D.C.

[9] B. Kumar, Scientist, Rigid Pavements Division, CRRI, "Design Construction & Quality Control Aspects in Concrete Road (ppt)".

[10] IRC: 15-2011, "Standard Specifications and Code of Practice for Construction of Concrete Roads (Fourth Revision)".

[11] IRC: 58-2011, "Guidelines for Design of Plain Jointed Rigid Pavement for Highways (Third Revision)".\

[12] Indian Road Congress, IRC: 58-2002, Guidelines for the Design of Plain Jointed Rigid Pavement for Highways.

[13] IRC: 57-2006, "Recommended Practice for Sealing of Joints in Concrete Pavements (First Revision)".

ISSN : 2455-9679
Impact Factor : 2.015

[14] Detailed Project Report, "Upgradation of Road from Nathusari Kalan to Rupana Bishnoian in Sirsa", Haryana PWD (B&R), 2014.

[15] Standard Specification for Urban Infrastructure Works 5-18 Edition 1, Revision/ September 2002