Comparison of Effective CBR Value between Japanese Formula and Elastic Two Layer Theories

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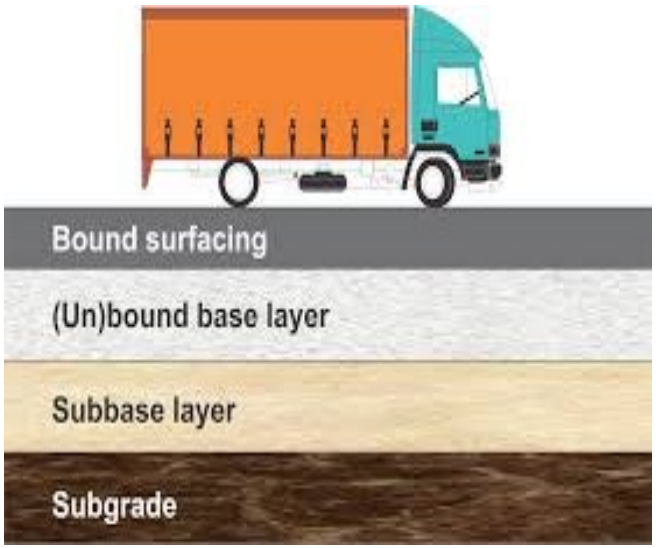
❑ SOIL SUBGRADE



"The upper 500 mm of soil, whether in embankment or in cutting, compacted to a higher density than that of the native soil below it is considered as the subgrade of pavement."

Important parameters to characterize subgrade are:-

- CBR
- Resilient modulus
- Modulus of subgrade reaction

❑ EFFRCTIVE CBR

- Composite strength of the subgrade and the embankment soil below it is termed as **EFFECTIVE CBR.**
- This composite strength should be taken for design consideration rather than strength of top 500mm.
- AASHTO (1993) recommended following equation for determining strength of subgrade as:

$$Mr = 10 \times CBR \text{ for } CBR \leq 5$$

$$Mr = 17.6 \times CBR^{0.64} \text{ for } CBR > 5$$

LITERATURE REVIEW

- Basic concept of effective CBR was developed by **Japan Road Association** and formulated an equation for getting effective CBR.

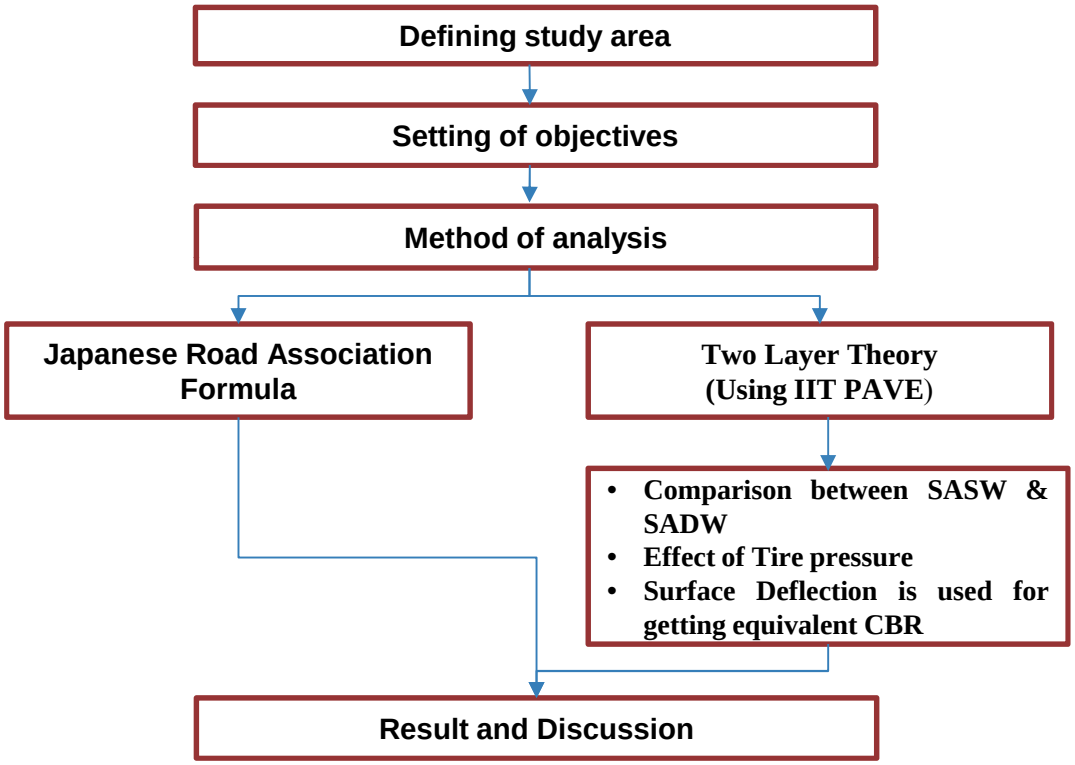
$$CBR_{Equiavalent} = \left[\frac{\left[H_1 \times (CBR_1)^{(1/3)} + H_2 \times (CBR_2)^{(1/3)} \right]}{\left[H_1 + H_2 \right]} \right]^3$$

- Reddy et. Al. 2001 analyszed subgrade surface deflection under the action of a single wheel load computed using layered elastic theory and developed charts of various combination to find out effective CBR.

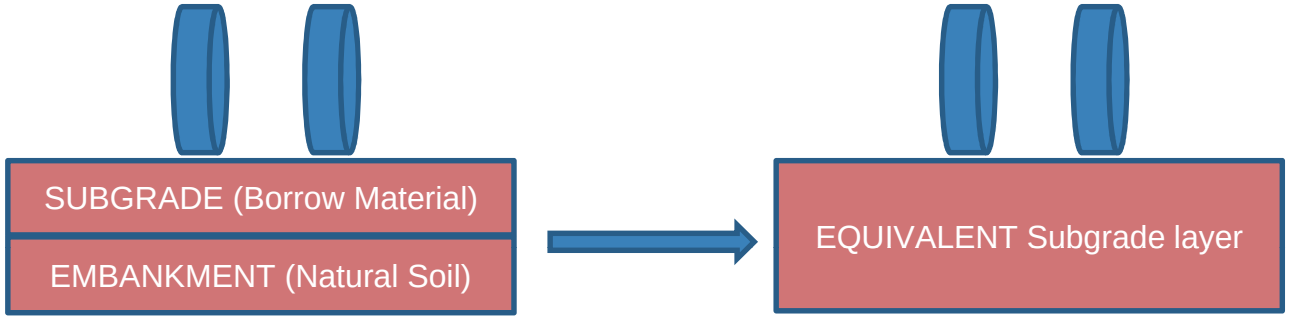
OBJECTIVES

- Comparing effective CBR from japanese formula and two layer theory
- Effect of varrying subgrade thickness on effective CBR.
- Effect of varying tire pressure on effective CBR
- Effect of weak subgrade over strong embankment material.

PROPOSED METHODOLOGY



TWO LAYER ANALYSIS



Eqaution used for corelating surface delection with pavement equivalent strength as:

$$\omega = \frac{2(1-\nu^2)qa}{E}$$

Where ,

ω : surface deflection

q : tire pressure

a : raidus of contact area

MODELS FOR ANALYSING SADW

- **Model 1: Equivalent single Axle Radius**

The basic concept is to determine a single tire load with an equivalent radius that would lead to the same response if the loaded by the same total load as the dual tire assembly

$$a_{eq} = a[1 + 0.241683 \times \frac{s}{a}]$$

- **Model 2: Equal Contact Pressure Concept**

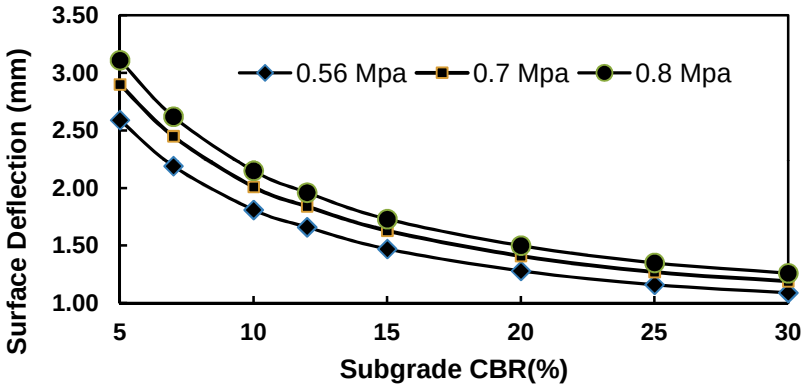
It is assumed dual tire will be considered as single tire with same pressure and same area.
2P/2A=2P/A' i.e., A'=2A.

RESULTS

- Effective CBR Value Based on Japanese Formula

Subgrade CBR (%)	Effective CBR for Different Embankment CBR (%)							
	5	7	10	12	15	20	25	30
5	5.00	5.94	7.21	8.00	9.10	10.83	12.44	13.97
7	5.94	7.00	8.41	9.28	10.50	12.39	14.15	15.81
10	7.21	8.41	10.00	10.97	12.33	14.43	16.37	18.21
12	8.00	9.28	10.97	12.00	13.44	15.66	17.71	19.65
15	9.10	10.50	12.33	13.44	15.00	17.38	19.58	21.64
20	10.83	12.39	14.43	15.66	17.38	20.00	22.41	24.66
25	12.44	14.15	16.37	17.71	19.58	22.41	25.00	27.42
30	13.97	15.81	18.21	19.65	21.64	24.66	27.42	30.00

Impact of tire pressure on effective CBR for Front Wheel damage for wheel Load of 32500N for Subgrade Thickness of 500 mm



Embankment CBR of 5%			
Subgrade CBR	Single Axle with Single Tire		
	0.56 Mpa	0.7 Mpa	0.8 Mpa
5	5	5	5.1
7	6.6	6.6	6.7
10	8.7	8.9	8.9
12	10.0	10.2	10.3
15	11.9	12.1	12.3
20	14.6	15.1	15.3
25	17.1	17.8	18.1
30	19.4	20.2	20.7

Comaparison between SASW and SADW

Embankment CBR	Subgrade CBR	Compressive strain		
		Single Axle Dual Tire		Single Axle Single Tire
		Model 1	Model 2	
10	15	0.1022E-02	0.1503E-02	0.1512E-02
15	20	0.8624E-03	0.1263E-02	0.1268E-02

Embankment CBR	Subgrade CBR	Effective CBR (Based on two layer theory)		
		Single Axle Dual Tire		Single Axle Single Tire
		Model 1	Model 2	
10	15	13.57	13.78	13.89
15	20	18.67	18.87	18.97

load considered in model 1 and 2 produce lesser CBR than that of the case of single axle with single tire. Therefore, the effect of SADW is not considered for the determination of effective CBR

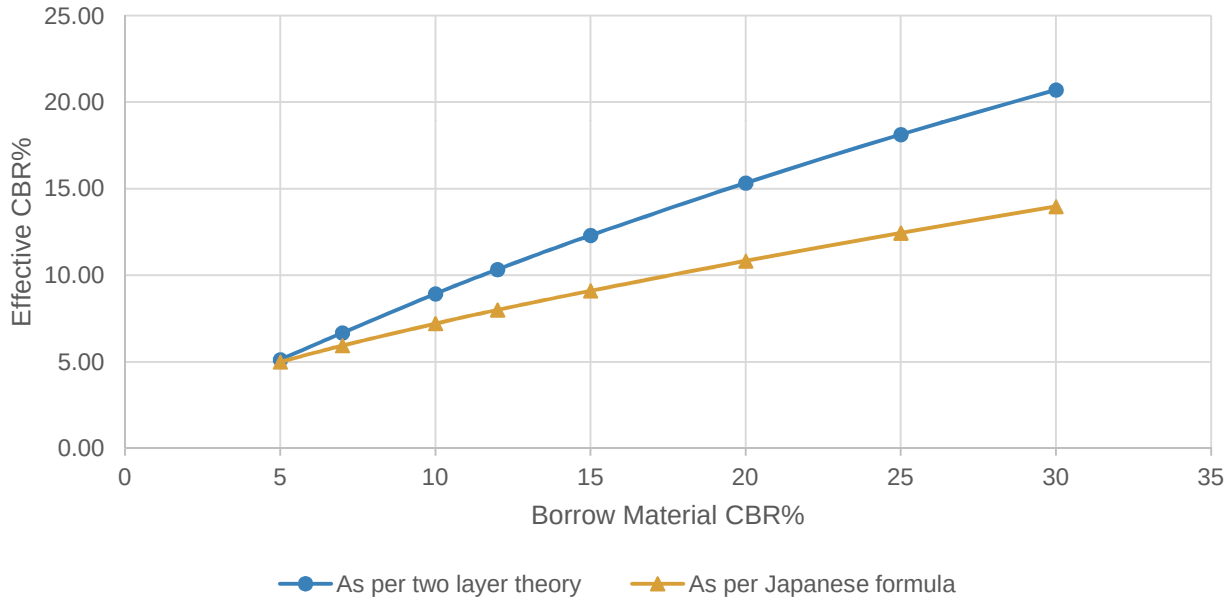
Effective Design CBR for Different Embankment CBR for 500 mm Subgrade as per two layer theory for SASW

Different axle load surveys across India and abroad, found that truck vehicle tire pressure is in the range of 110-120 PSI which is close to 0.8 MPa. Therefore, CBR at 0.8 MPa has been considered for pavement design from practical consideration.

Borrow Subgrade CBR (%)	EMB 5	EMB 7	EMB 10	EMB 12	EMB 15	EMB 20	EMB 25	EMB 30
5	5.12	5.35	5.59	5.70	5.82	5.97	6.07	6.14
7	6.67	7.01	7.37	7.53	7.73	7.95	8.11	8.23
10	8.93	9.46	10.01	10.29	10.59	10.96	11.22	11.42
12	10.33	10.98	11.69	12.02	12.41	12.87	13.21	13.46
15	12.30	13.15	14.06	14.51	15.03	15.65	16.10	16.43
20	15.33	16.50	17.78	18.40	19.12	20.02	20.68	21.18
25	18.12	19.59	21.23	22.04	22.99	24.18	25.03	25.72
30	20.70	22.48	24.48	25.46	26.67	28.11	29.21	30.05

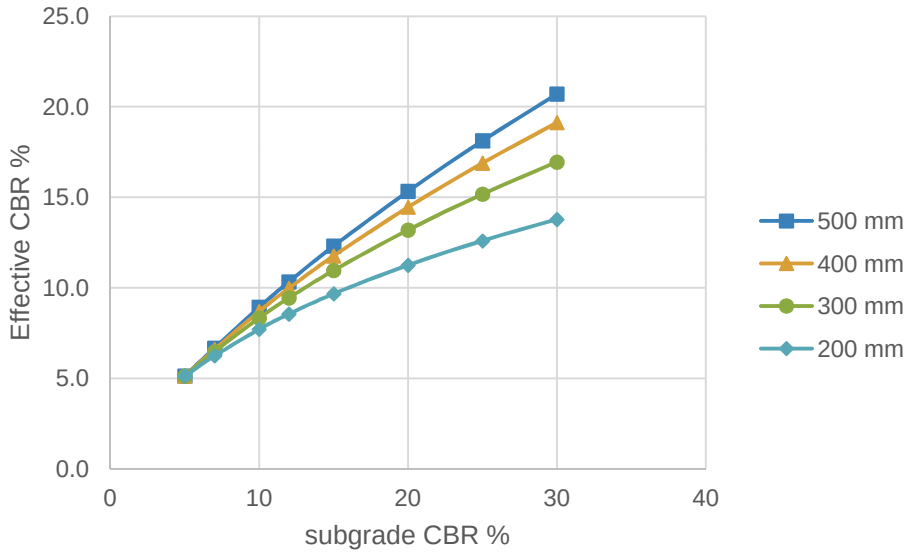
Comparison between Japanese formula and Two layer theory

Typical representation of variation in effective CBR for various borrow material CBR and embankment CBR of 5%.



Impact on effective CBR on varying subgrade thickness

It is found that effective CBR decreases with decreasing the subgrade thickness.



Effective CBR base on 5 % of embankment CBR				
Subgrade CBR(%)	Subgrade Thickness			
	500 mm	400 mm	300 mm	200 mm
5	5.1	5.1	5.1	5.1
7	6.7	6.6	6.5	6.2
10	8.9	8.7	8.3	7.7
12	10.3	10.0	9.4	8.5
15	12.3	11.8	11.0	9.7
20	15.3	14.5	13.2	11.2
25	18.1	16.9	15.2	12.6
30	20.7	19.1	16.9	13.8

CONCLUSION

- From Japanese Formula, CBR value increases with increasing value of subgrade CBR and maximum CBR archived when embankment CBR is equal to subgrade CBR.

- Japanese Equation recommended lower CBR due to consideration 500 mm subgrade and 500 mm embankment whereas two layers theories give higher value due the consideration of higher thickness of infinite depth.

- It is observed that Effective CBR increases with increasing tire pressure and not depended on feasible range of Poisson Ratio (0.35 to 0.4) of materials.

CONCLUSION

- It is found that damaging effect of SASW tire (Generally front axle) is more critical and SADW is lesser critical and therefore, single axle with single tire shall be considered for evaluation effective CBR.

- It is observed that effective CBR decreases with decreasing subgrade thickness. Therefore, higher subgrade thickness is better than that of lower subgrade thickness for same subgrade CBR.

- From variation of subgrade and embankment CBR, it is found that embankment CBR should be less than or equal to subgrade CBR and it should not exceed subgrade CBR Value for optimizing benefit.

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THANKS!

Any questions?