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Analysis of Rigid Pavement by Varying Thickness and Using RCA

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Abstract: ***The structural adequacy of rigid pavement can generally be get predicted based upon its structural response to the applied loads mostly in terms of deflection and stress, In the present study, Rigid roadway pavement is modeled as a rectangular plate supported by elastic soil foundation having sub grade modulus (K) which permits only downward deformation of mass i.e. no horizontal deformation. The class A static load is applied to pavement having different thickness from 150mm to 300mm and analysis using computer software STAAD-PRO and manually by Westergaard analysis theory performed and the results are obtained which shows inverse relation between thickness and deflection then analysis is further extent for pavement consist of 30 percent recycled concrete aggregate having different properties like density, modulus of elasticity and compressive strength are presented graphically for comparison study to clearly marks the green and sustainability concept and increase thickness provides eco-friendly economy, strength and increase life span to road pavement as well as safety to road user.***

Keywords: Rigid pavement, Elastic soil, sub grade modulus, Class A load, Recycled concrete aggregate

1. Introduction

India is a large country with huge number of resource and materials and If these materials are used wisely can leads to cut-down cost of construction. There are various types of pavements which mark their difference in their suitability into different environment and conditions. Each type of pavement has its own pros and cons. Even with availability of large number resources and knowledge the conditions of roads are not pretty good, due to earthquakes large numbers of roads get effected as they may get cracked or sink and disturbing the transportation facilities and leads to economic loss for nation so the analysis of pavement need to be holistic approach to prevent such losses and facilities and also In near future, the cost of bitumen will go on increasing hence alternatives to construct the roads are to be planned also sustainability and green concept needs to be incorporating by using some amount of rca (recycled concrete aggregate) into pavement.

1.1 Methodology

This include data collection, material properties, computer modeling, data analysis and Interpretation, In this study the analysis on rigid pavement is performed via computer software STAAD-PRO and manual method i.e. Westergaard's Theory for analyzing pavement.

1.2 Data model

The model for analysis is taken as:

Table 1: Data required for analysis.

• Type of pavement:	Rigid pavement
• Width of slab:	3.5m
• Length of slab:	11m
• Thickness of slab:	150mm,200mm, 250mm,300mm
• Load acting:	class-A
• Soil spring support:	18000 kg/m^2
• Load type:	single axle
• Grade of concrete:	M-30
• Stress compute:	Wheel stress
• Density of concrete Normal concrete:	2414 kg/m^3
• Density of concrete RCA:	2009 kg/m^3
• Young's modulus Normal concrete:	27386 Mpa
• Young's modulus RCA:	22400 Mpa
• Poisson ratio (μ):	0.17

1.3 Computer modeling

Staad-pro is used to perform analysis in which rigid pavement is modeled as concrete plate resting on soil medium represented by spring support system and class A load is applied on pavement

1.4 Class A load

Class A loading consists of a wheel load train composed of a driving vehicle and two trailers of specified axle spacing. This loading is normally adopted on all roads as referred to IRC: 6 - 1966 – Section II.

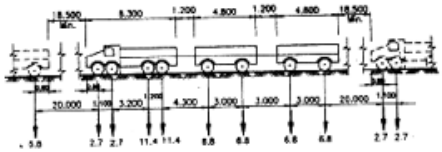

Figure 1: The class A load diagram

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1.5 Manual modeling

Westergaard's Theory is used to perform manual calculation in which there are three formulas have been present to calculate stresses at three different location i.e. interior, edge and corner areas but in this only interior loading condition to get analysis results, Westergaard considered the rigid pavement slab as a thin elastic plate resting on soil sub-grade,

$P(\text{interior}) = 0.316P/H^2 * [4\log_{10}(L/B) + 1.069]$

$P(\text{edge}) = 0.572\ P/H^2 * [4\log_{10}(L/B) + 0.359]$

$P(\text{corner}) = 3P/H^2 * [1-(A\sqrt{2}/L)]$

Where H,A,B,L are slab thickness, radius of wheel, equivalent radius of resisting section and length of slab respectively.

1.6 Data Analysis

Initiating the analysis into two sections, In first section the pavement with normal aggregate properties and M-30 grade is used and in second the rca is used with some different properties then the analysis is performed on pavement model having different thickness ranging 150mm, 200mm, 250mm and 300mm, the modeling results of stress and deflection are on critical nodes and area region are shown below

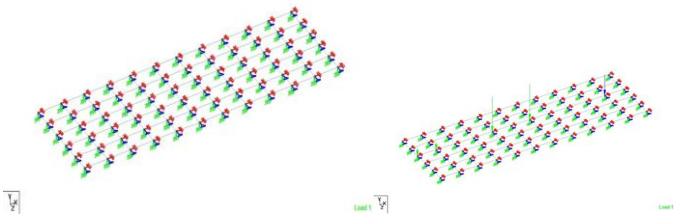

Figure 2 (a): pavement model **Figure 2(b):** Loading Diagram

1.6.1 Section 1: with normal concrete aggregate, Taking slab thickness of 150 mm and got stress diagram and deflection diagram as

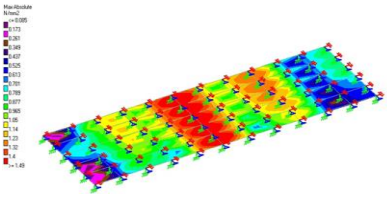

Figure 3(a) stress diagram of 150mm normal pavement

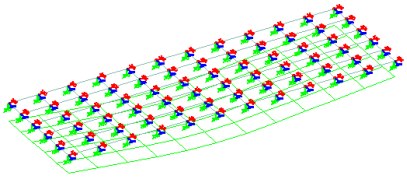

Figure 3 (b) deflection diagram of 150mm normal pavement

Taking slab thickness of 200 mm and got stress diagram and deflection diagram as:

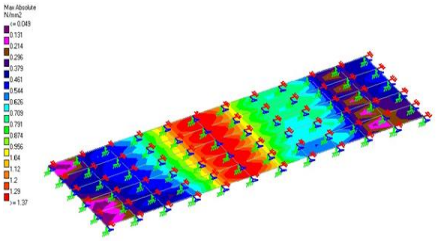

Figure 4 (a): Stress diagram of 200mm normal pavement

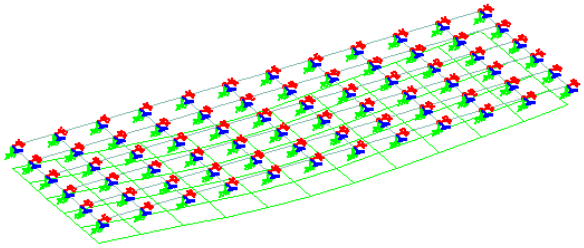

Figure 4(b) deflection diagram of 200mm normal pavement

Taking slab thickness of 250 mm and got stress diagram and deflection diagram as:

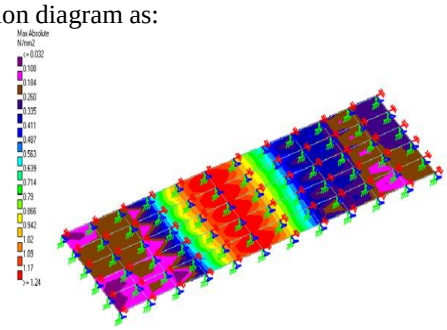

Figure 5 (a): Stress diagram of 250mm normal pavement

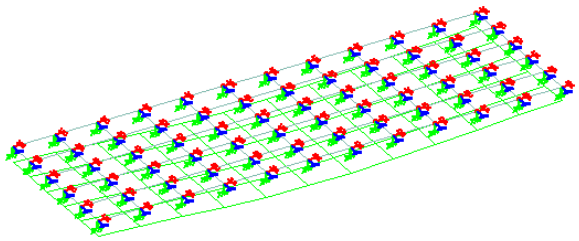

Figure 5(b): Deflection diagram of 250mm normal pavement

Taking slab thickness of 300 mm and got stress diagram and deflection diagram as:

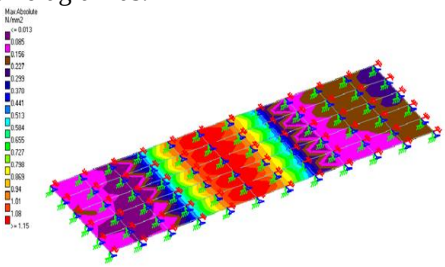

Figure 6 (a): Stress diagram of 300mm normal pavement

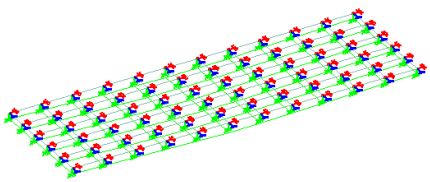

Figure 6 (b): Deflection diagram of 300mm normal pavement

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1.6.1 Section 2: with recycle concrete aggregate. Taking slab thickness of 150 mm and got stress diagram and deflection diagram as:

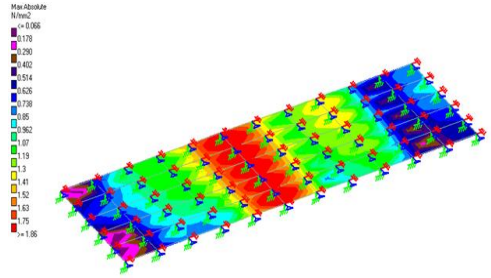

Figure 7(a): Stress diagram of 150mm RCA pavement

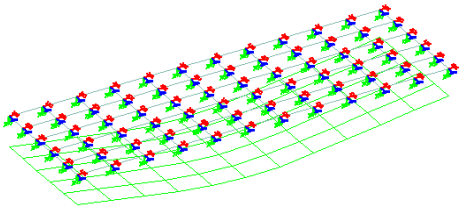

Figure 7 (b): deflection diagram of 150mm RCA pavement

Taking slab thickness of 200 mm and got stress diagram and deflection diagram as:

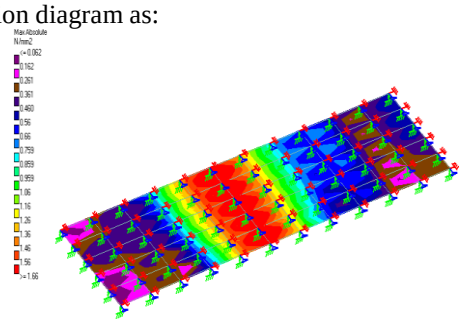

Figure 8 (a): Stress diagram of 200mm RCA pavement

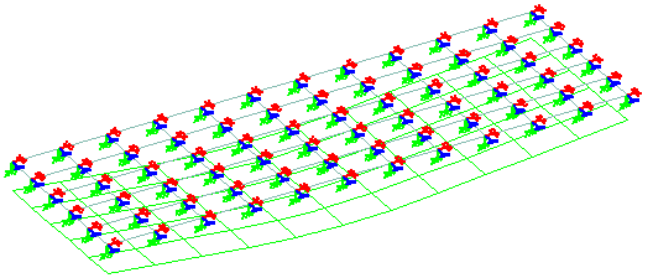

Figure 8 (b): Deflection diagram of 200mm RCA pavement

Taking slab thickness of 250 mm and got stress diagram and deflection diagram as:

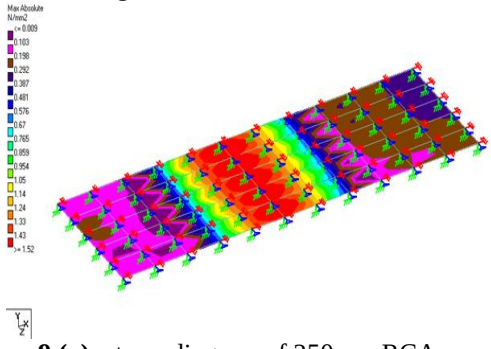

Figure 9 (a): stress diagram of 250mm RCA pavement

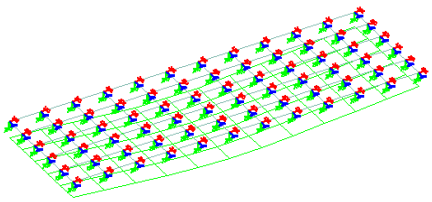

Figure 9 (b): deflection diagram of 250mm RCA pavement

Taking slab thickness of 300 mm and got stress diagram and deflection diagram as:

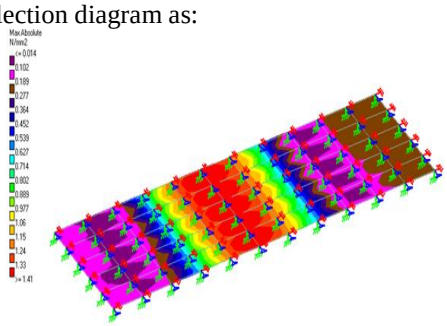

Figure 10 (a): stress diagram of 300mm RCA pavement

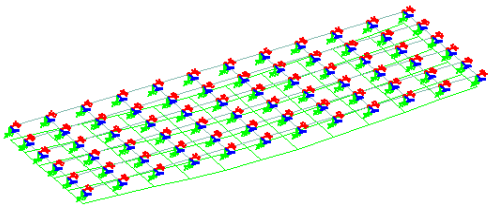

Figure 10 (b): deflection diagram of 300mm RCA pavement

2. Result and Outcomes

A) Effect of change in thickness on pavement

In this the class A load is applied on pavement made up normal concrete aggregate with M-30 grade, poisson ratio 0.17, density 2414 kg/m^3 and soil represented by spring constant or sub grade modulus which on analyzing with staad-pro computer software found that with increase in thickness of pavement the deflection and stress values goes on decreasing and result is further analyze by westergaard's analysis which shows almost similar value as computer analysis.

B) Effect of change in material of pavement (RCA)

On replacing normal aggregate with 30 percent recycled concrete aggregate having different compressive strength, density and elastic modulus which on analyzing with similar condition as with normal concrete aggregate and with increase in thickness found that stress value and deflection goes on decreasing with increase of thickness but also found that these values are slight higher than normal aggregate almost 8-12% although is under permissible limit can states that we can use RCA as pavement material which will prove to be environmental friendly because it is usually made up of old concrete from sidewalks, pavements, curbing and building slabs, and also cheaper which will justify sustainability and green concept. Representing above stress analysis results in tabular manner as:

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Table 2: 150 mm pavement stress result

Shaded Region	Stress (N/mm²) analysis	STAAD-PRO	Stress (N/mm²) Westergaard's method
	Normal aggregate	RCA	Normal aggregate
	0.261	0.290	0.342
	1.49	1.86	2.631
	0.349	0.402	0.815

Table 3: 200 mm pavement stress result

Shaded Region	Stress (N/mm²) analysis	STAAD-PRO	Stress (N/mm²) Westergaard's method
	Normal aggregate	RCA	Normal aggregate
	0.214	0.261	0.314
	1.37	1.66	2.080
	0.296	0.361	0.672

Table 4: 250 mm pavement stress result

Shaded Region	Stress (N/mm²) analysis	STAAD-PRO	Stress (N/mm²) Westergaard's method
	Normal aggregate	RCA	Normal aggregate
	0.184	0.198	0.287
	1.24	1.52	1.984
	0.260	0.292	0.384

Table 5: 300 mm pavement stress result

Shaded Region	Stress (N/mm²) analysis	STAAD-PRO	Stress (N/mm²) Westergaard's method
	Normal aggregate	RCA	Normal aggregate
	0.156	0.189	0.214
	1.15	1.41	1.757
	0.227	0.277	0.269

Representing above deflection value analysis results in tabular manner as:

Table 6: deflection values of normal aggregate concrete pavement

Node no./ Pavement thickness	1	74	15	11	19
150 mm	3.629	3.246	6.136	6.029	6.000
200 mm	3.159	2.854	5.998	5.165	5.173
250 mm	2.783	2.561	5.927	4.821	4.777
300 mm	2.595	2.370	6.025	4.376	4.283

Table 7: Deflection values of recycled aggregate concrete pavement

Node no./ Pavement thickness	1	74	15	11	19
150 mm	4.310	3.883	6.664	6.120	6.000
200 mm	3.685	3.329	6.421	6.000	5.900
250 mm	3.139	2.877	6.226	5.259	5.252
300 mm	2.768	2.562	6.165	4.775	4.681

2.1 Graphical interpretation of results calculated above have been shown below:

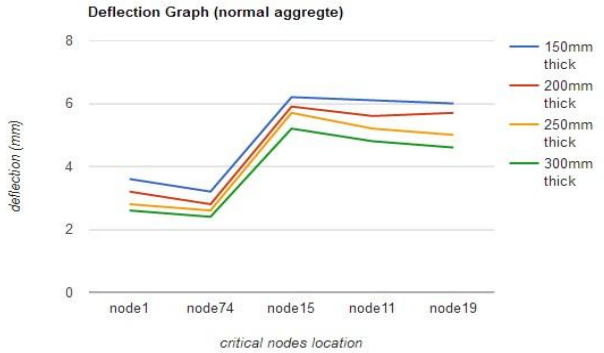

Figure 13: Graph showing analysis result of normal aggregate concrete pavement

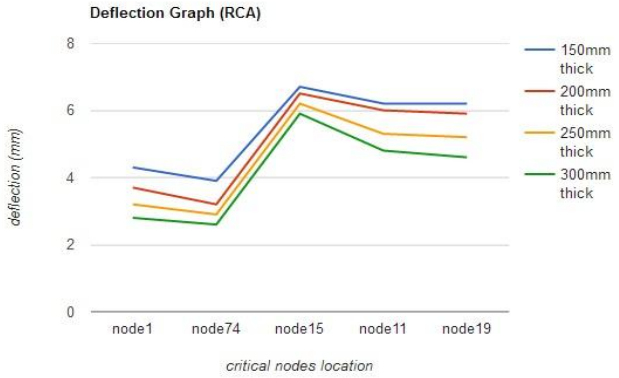

Figure 14: Graph showing analysis result of RCA pavement

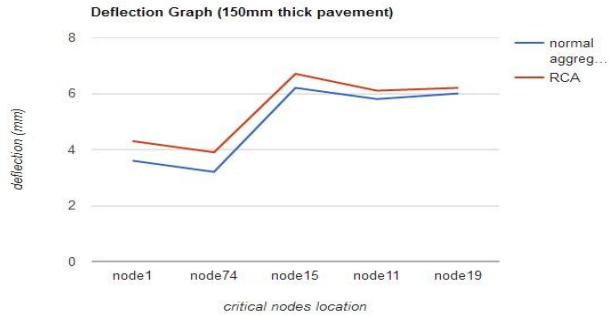

Figure 15: Graph showing analysis result of 150mm thick pavement

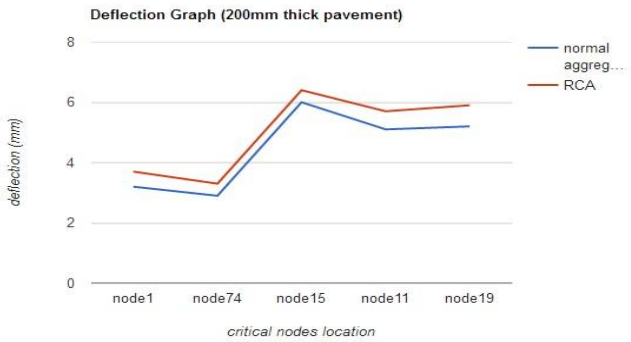

Figure 16: Graph showing analysis result of 200mm thick pavement

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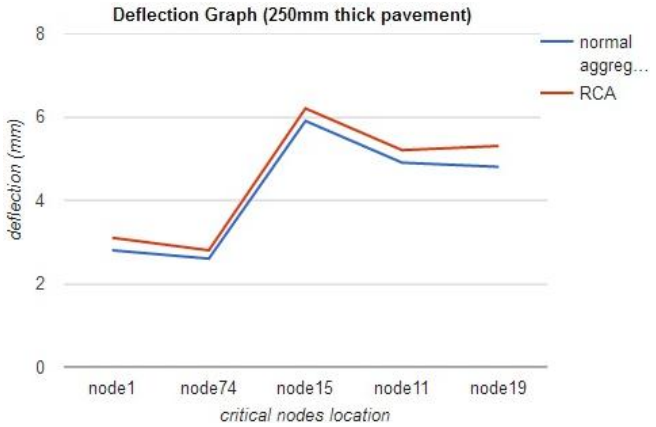

Figure 17: Graph showing analysis result of 250mm thick pavement

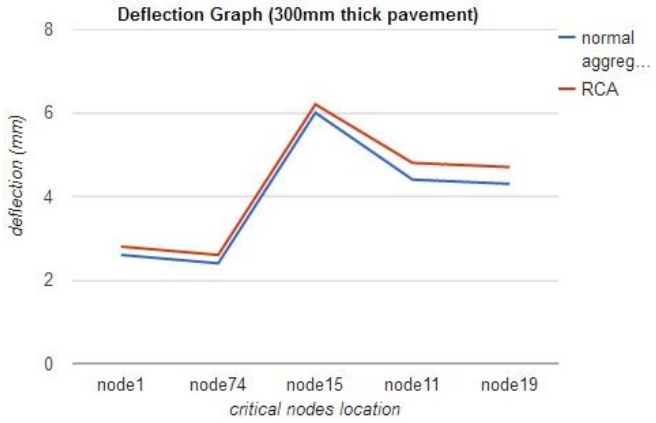

Figure 18: Graph showing analysis result of 300mm thick pavement

3. Conclusions

In this study analysis of road is done and find out the response of pavement to loading by computer software and manual method, it has been observed that thickness of pavement is inversely proportional to deflection and stress so if deflection range and stress induced in it reduces the roads will not sink under loading or during earthquake because when roads get fail there huge loss of economy and time takes place.

There should be properly analysis of pavement takes place by foreseeing the future traffic condition and proper thickness and load condition should be imposed on design model and then the construction of roads takes place, In this also the study about pavement made up of normal aggregate concrete and pavement made up of recycle aggregate concrete is done and the result values are compared which found to be differ by 8-12% which is under permissible limit but by using 30 percent rca into pavement we can able to cut down cost as well as save the environment by using recycled product and also follow the sustainability concept which is demand of today's world.

Acknowledgement

I respect and thank Amity University, Noida, for giving me an opportunity to do the major project work in "ANALYSIS OF RIGID PAVEMENT BY VARYING THICKNESS AND USING RCA" and providing me all support and guidance which made me complete the project on time . I heartily thank my internal project guide, Mr. N.B Mishra (professor), Department of civil engineering, for his guidance and suggestions during this project work.

References

[1] Sawant V (2009)," Dynamic analysis of rigid pavement with vehicle–pavement interaction, Vol. 10, pp 63-72.
[2] Alisjahbana S.W & Wangsadinata W (2012)," Dynamic analysis of rigid r pavement under moving traffic loads with variable velocity", Interaction and Multiscale Mechanics, Vol. 5, pp 105-114
[3] Muhammad et al (2013), "Behavior of a Rigid Pavement Under Moving Dynamic Loads", transportation research record- 1307, pp 129-135.
[4] Patil V et al (2013), "3D Finite-Element Dynamic Analysis of Rigid Pavement Using Infinite Elements, International Journal of Geomechanics,Vol 13 pp. 533-544.
[5] Salman M & Patil S (2014)," Analytical Study of Steel Fibre Reinforced Rigid Pavements Under Moving Load", International Journal for Scientific Research & Development, Vol. 2,, pp 467-475.
[6] Belekar Y & Mullani I (2015)," Effect of Dynamic Load on Rigid Pavement", International Journal of Engineering Research & Technology (IJERT), Vol. 4, pp 287-290.
[7] Solanki P & Zaman M (2016)," Design of semi rigid type of flexible pavements, international journal of pavement research and technology,Vol. 2, pp 1-13.
[8] Seyedhamed Sadati & Kamal H. Khayat (2016)," field performance of concrete pavement incorporating recycled concrete aggregates,journal of elsevier-construction and building material Vol. 126, pp 691-700.
[9] Darestani M.Y et al3 (2016)," Experimental Study On Structural Response Of Rigid Pavements Under Moving Truck Load", 22nd ARRB Conference – Research into Practice, Canberra Australia, 2006
[10] Beskou N.D et al 2 (2016)," Dynamic elastic analysis of 3-D flexible pavements under moving vehicles", Soil dynamics and Earthquake engineering, Vol. 82, pp 63-72.

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