

Assessment of Pavement Condition Index of The Federal Polytechnic Ado-Ekiti Campus Roads, Ekiti State, Nigeria

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Abstract: Roads are built as infrastructure to facilitate mobility and accessibility of socio-economic activities in society. Highway is very essential in that it support the growth rate of the economy, agriculture, education and other sectors. Considering the benefits of road in economy growth, matters related to the development and maintenance of roads are a priority to be researched and developed in planning, implementing and maintaining them. One of the research targets is the paved roads within the Federal Polytechnic Ado Ekiti campus, which suffered significant defects, both minor and moderate damage. Although recently, most of these roads were rehabilitated but presently these roads are characterized by one defect or the other evidently noticed by some types of cracks on the surface of the pavements. The purpose of this study is to determine the type, extent and severity of these damages to the road surface, and then suggest measures for maintenance of these roads in order to optimize the durability of the roads. The application of the PCI is carried out by visual survey at the research location, determining the type and level of damage and measuring the damage dimensions which include length, width and depth, calculating the area of damage, analyzing the damage condition. The results of the analysis of the campus roads are classified with an average PCI value of 65. The appropriate improvement strategy suggested is routine maintenance.

Keyword: Distress, Pavement condition index, extent, severity, deduct value.

I. Introduction

Recently, most of the roads within the campus have been rehabilitated. However, most of these roads are now characterized by one form of distress or the other. In general, road damage such as crack including alligator cracking and blocking cracking, and edge cracking etc., pothole, and raveling are predominantly present on the road. Road damages like this are usually caused by a variety of factors, such as traffic loading, high groundwater conditions, the consequences of wrong construction time, less quality materials, poor workmanship or skill, environmental factors like temperature and rainfall and planning errors (Carey,1960). Road pavement is a pavement layer that is located between layers of subgrade and wheel of the vehicle. It serves to provide services to the means of transportation and it is expected that during the service period of the pavement there will be no significant damage. Therefore, it is necessary to know the cause of the damage and how to maintain the road. In order to create a safe and comfortable roadway and provide significant benefits for the sustainability and survival of the wider community it becomes imperative to regularly monitor and maintain the pavement surface (Haas, 1994). Theoretical and empirical studies show that all road users certainly want the road used to be safe, clean and give riding comfort to it users at all time. Therefore, the damage that occurs on the road must be addressed and repaired on time. This will prevent excessive damage that will require extensive repair and cost. The method used to analyze the pavement condition in this study is the pavement condition index that provide useful information to the road engineers about appropriate handling strategies to be implemented on the road.

II. Literature review

Definition of road

Road is a path designed for passage of vehicle, pedestrians. According to the Federal Highway Administration (FHWA), roads is an essential part of the transportation infrastructure that provide connectivity and accessibility for people and goods (FHWA,2022). According to Law No. 38 of 2004 concerning roads, in accordance with their designation, the road is distinguished by special roads and public roads, both of which are the lifeblood of people's lives in an effort to develop national and state life (Sabaruddin,2020).

Pavement condition index (PCI)

The pavement condition index is the numerical rating ranging from 0 to 100 that evaluates the condition of a pavement surface. It considers various types of distresses such as: cracking, bleeding pothole raveling etc. Pavement condition index (PCI) assess road pavement conditions by type, the level of damage, and severity of the damage that occurs. The pavement condition score helps to assess pavement condition, prioritize maintenance strategies, determine rehabilitation needs and also evaluate the pavement performances. There are several methods available to evaluate pavement condition including Visual Inspection and Measurement (VIM), Ground Penetrating Radar (GPR), Falling Weight Deflectometer (FWD), Dynamic Cone Penetration Test (DCPT), Acoustic Testing, and Pavement Scanning. Most of these methods mentioned are used to evaluate the pavement condition structurally. However, visual inspection and measurement method is a very simple and easy to adopt method usually used to assess the pavement condition functionally. Periodic conducting condition surveys, information on pavement conditions can be useful for predicting future performance, as well as more detailed measurement input. Study of pavement surfaces helps in developing Pavement

Condition Index. PCI is an indicator of present condition of pavement which is directly related to pavement surface operational condition. PCI ranges from 0 to 100, 100 representing very good condition and 0 representing worst condition. PCI value gives an idea to public work officials about current condition of pavement and rate of deterioration of road network. Deduct value method is used to find value of PCI.

Severity level

The severity level is a mean of categorizing the severity of pavement distresses to each type of distresses. The severity level used in calculating PCI is low severity level (L), medium severity level (M) and high severity level (H). Low severity (L) indicates minor distresses that do not significantly affect the pavement performance. Medium severity is a moderate distress that begin to impair pavement performance while high severity is a sever distresses that significantly impact the pavement safety and functionality.

III. Methodology

Description study area

The research area was carried out within the Federal Polytechnic Ado-Ekiti campus. The roads included eleven major roads within the campus. The general description of the selected roads is given in Table 1.

Table 1: Description of All Roads

S/N	LOCATION	ROAD LENGTH (m)	ROAD WIDTH (m)	AGE (YEARS) (CONSTRUCTED OR LAST REHABILITATED)
1	Poly Gate- Abuja Roundabout	585	7.5	10
2	Abuja Roundabout-Engineering Road	500	8	4
3	Abuja Hostel- Chief Lecturer Office Road	880	7.5	3
4	Science Tech-Digital Library Road	650	7.5	4
5	SecurityOffice – Digital Library	350	7.5	4
6	Central Gen. - Abuja Roundabout	830	8	-
7	Abuja Roundabout- Abuja Hostel	350	6.8	-
9	Staff school road	480	7.0	-
11	Motion Ground Road	200	7.5	2

Data processing

Distress surveys are performed to evaluate the degree of physical pavement deterioration, which is a function of; type of distress, severity of distress and extent of distress (amount or density of distress). Each of the three aforementioned characteristics of pavement distress has a significant influence on the determination of the overall pavement deterioration. Because there are many types of distresses and a variety of ways to define severity levels and extent measurement, it is important to use or adapt standard procedures for distress identification and measurements of extent at each severity level (fwa, 2006).

Data processing is done to identify the type of damage and its severity based on the level of damage obtained from the road condition survey. The steps for conducting condition surveys and determining PCI ratings are carried out according to the ASTM D 6433, The pavement section under study was divided into sample units of 50m length. Surface inventory was done on each sample unit. Inventory includes noting down severity levels (low, medium, high) of different distresses present. The sample unit was inspected and distress type and severity level was determined. The density was then computed after finding severity levels. Distress density is the amount of distress present divided by sample unit area taken for bituminous pavement The formular for density is given in equation 1. The deduct values were then determined from the deduct value curves for each distress type and severity. Deduct values have a range from 0 to 100. A total deducts value (TDV) was computed by summing all individual deduct values. As the TDV was computed, the corrected deduct value (CDV) was then determined from the correction curves. Correction curves were used to determine the Corrected deduct value from total deduct value. When determining the CDV, if any individual deduct value is higher

than the CDV, the CDV is set equal to the highest individual deduct value. The correction curves used vary by q (no. of deduct value >5 points) values. After finding corrected deduct value, PCI was evaluated as $PCI=100-CDV$ where CDV is corrected deduct value. Similarly, PCI for all other sample units was calculated and final PCI was computed by taking average of all PCI values, using $PCI = \sum PCI(s) / N$, where N is number of units PCI values obtained are used to assess pavement conditions.

Density = $\frac{\text{Distress amount in (m}^2\text{)}}{\text{Sample unit area in (m}^2\text{)}} \times 100$

Sample unit area in (m²)

(1)

Typical deduct value graph for some distress type on flexible pavements are presented in figure 1-3. Alligator or crocodile cracking, rutting, and pothole deduct value graph are presented in figure 1-3 respectively. Figure 4 showed a typical corrected deduct values graph.

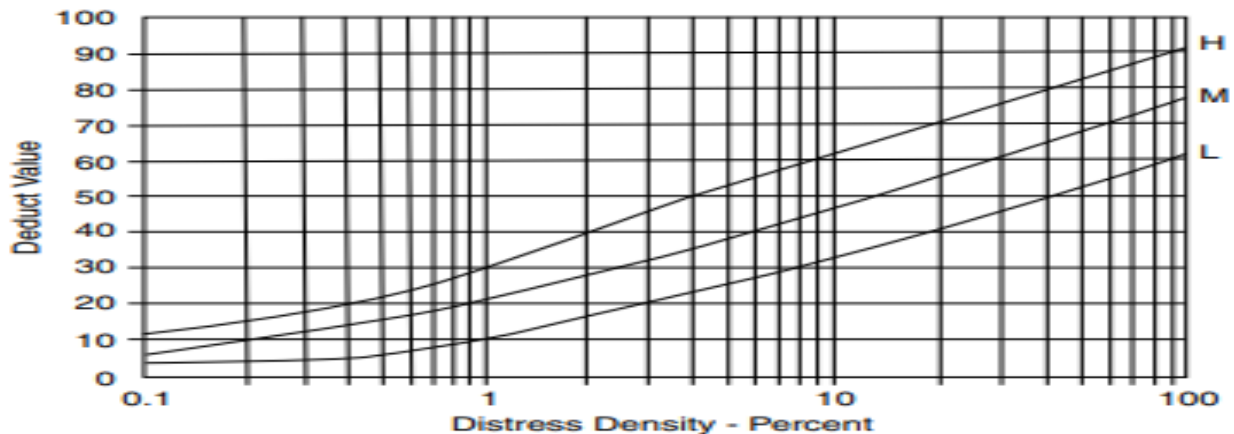


Figure1: Deduct value curves for crocodile cracks in flexible pavements (Source: Shahin and Walther, 1990).

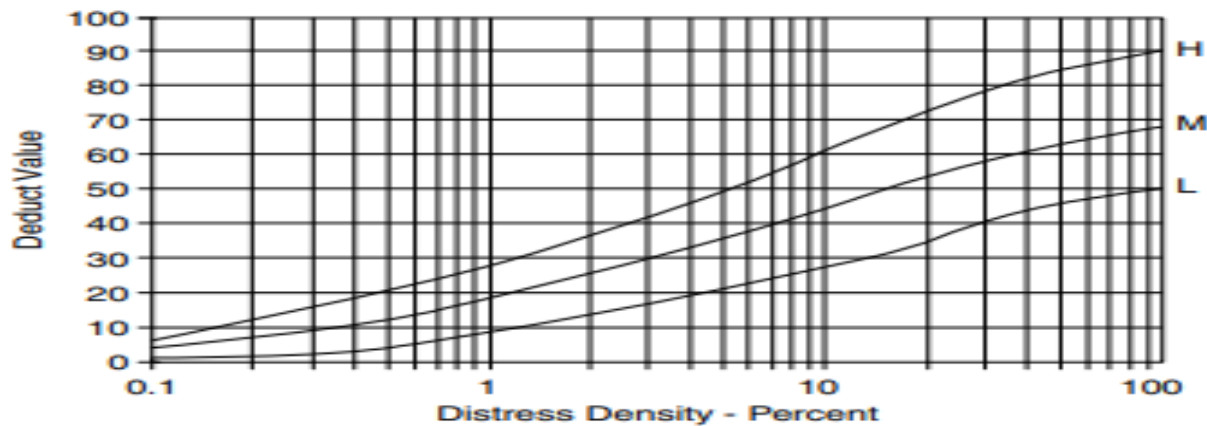


Fig 2: Deduct value curves for rutting in flexible pavements (Source: Shahin and Walther, 1990).

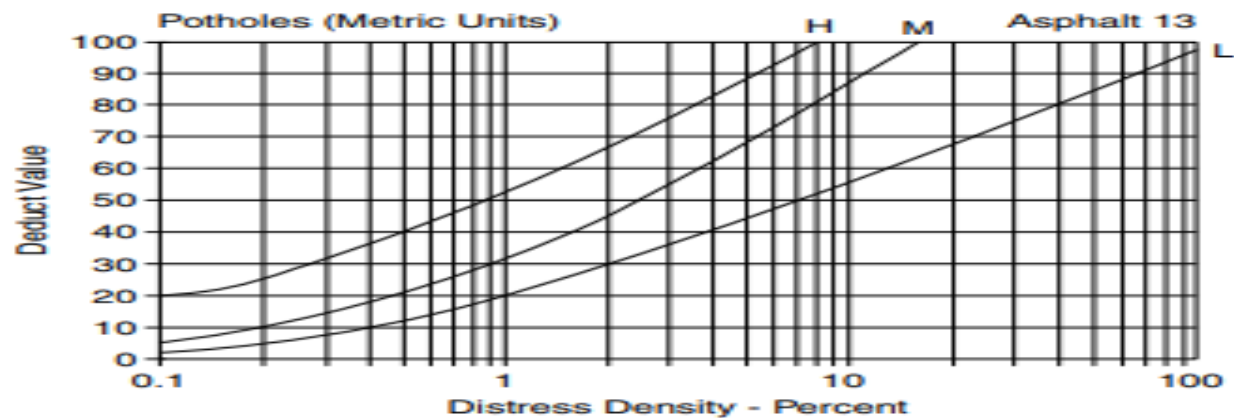


Fig 3: Deduct value curves for pothole in flexible pavements (Source: Shahin and Walther, 1990).

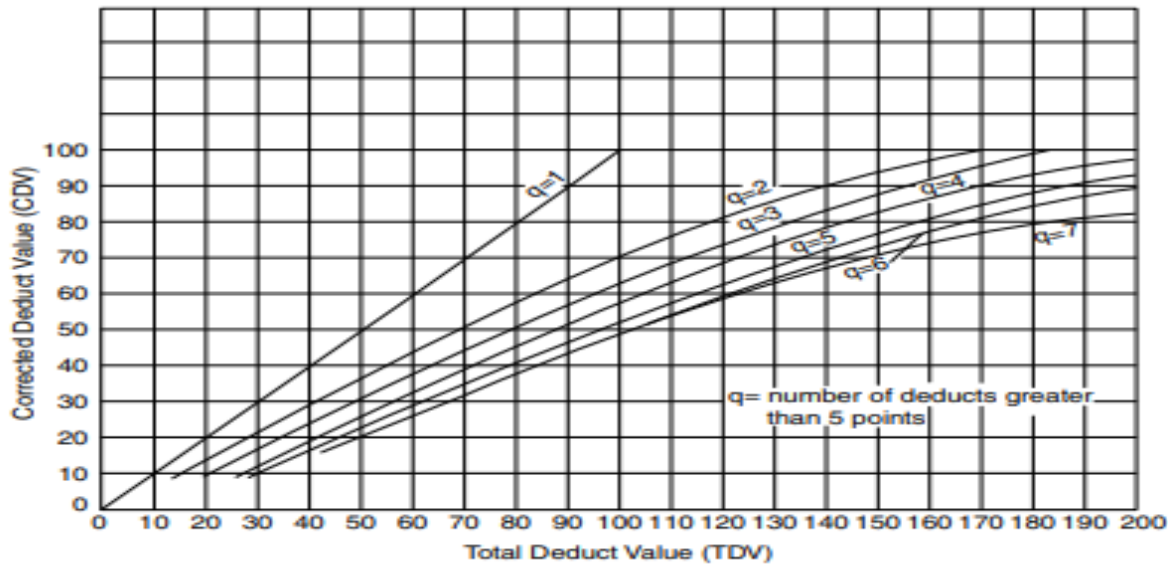


Fig 4: Corrected deduct value curves for flexible pavements (Source: Shahin and Walther, 1990).

The rating metrics of the pavement condition index used as per ASTM D 6433, is shown in the table 2.

Table 2: Pavement Condition Index Rating

PCI	Rating	Treatments
0 – 10	Failed	Reconstruction
11 – 25	Very poor	Reconstruction
26 – 40	Poor	Periodic
41 – 55	Fair	Routine
56 – 70	Good	Routine
71 – 85	Very good	Routine
86 – 100	Excellent	Routine

IV. Result and Discussion

The summary result of assessment of pavement condition performance for all the roads studied is presented in Table 3. Detail of how the parameters were determined was presented for better understanding were as shown in the appendix. The bar chart of the PCI value of all the roads was presented in Figure 5. From the results, it was observed that cracking is more prevalent in most of the roads ranging from block cracking, alligator cracking, longitudinal cracking, transverse and edge cracking. For road 1, block cracking is the major defect on the road taking a total percentage of 49.23%. This may be as a result of poor surface camber and drainage system as noticed on the road section. Delamination defect took 0.32%, pothole was 0.22%, alligator cracking was 8.92%, while joint reflective cracking was 41.3%. For road 2, joint reflection and longitudinal cracking are the major distresses noticed on the road which are about 68.42% and 24.21% respectively. These distresses noticed can be associated with thermal, fatigue and construction problem. For road 3, edge cracking and block cracking are more predominant taking 82.7% and 16.37% respectively. This can be resulted from environmental effect such as temperature, rainfall and poor construction in form of inadequate compaction of the road surface during construction. For road 4, block cracking both low and medium severity are noticed on the road, taking 87.36% of the total road distress. This type of distress that was predominant on this road can be as a result of high water level in the area. The road passes through a major water logged area of the campus. For road 5, edge cracking and block cracking were predominant on the road taking a total of 52.03% and 45.72% of the road area respectively. Longitudinal cracking was also noticed on the road. The possible cause of cracking on this road can be temperature fluctuation, insufficient thickness or material strength, construction issues, settlement of the underlying layers and weak or unstable subgrade causing pavement distress. For road 6, the only distress observed is edge cracking which may be resulted from construction problem or underlying problems. Road 7 and 8 are dual carriageways, the most significant distress observed there were joint reflective cracking and raveling. The possible cause of raveling may be aging and poor material. For road 9 and 10 which are also dual carriageways, raveling is 100% prevalent on the road. The surfaces are rough and possess high surface texture. This may be as a result of weak aggregate.

Table 3: Summary result of the PCI rating and maintenance type

Description of Road	Identification Number	Pavement condition index	Rating	Maintenance Type
Campus Main Gate-Abuja Roundabout Road (RH)	RD1	35	Poor	Periodic
Campus Main Gate-Abuja Roundabout Road (LH)	RD2	70	Good	Routine
Abuja Roundabout-Engineering Road	RD3	84	Very Good	Routine
Abuja Hostel - Chief Lecturers' Office Road	RD4	77	Good	Routine
Science Tech.-First Bank Road	RD5	60	Good	Routine
Security Office-Digital Library Road	RD6	90	Excellent	Routine
Central Gen.- Abuja Roundabout Road (RH)	RD7	55	Fair	Routine
Central Gen.- Abuja Roundabout Road (LH)	RD8	75	Good	Routine
Abuja Roundabout-Abuja Hostel Road (RH)	RD9	35	Poor	Periodic
Abuja Roundabout-Abuja Hostel Road (LH)	RD 10	35	Poor	Periodic
Staff school Road	RD 11	20	Failed	Reconstruction
Motion Ground Road	RD12	96	Excellent	Routine

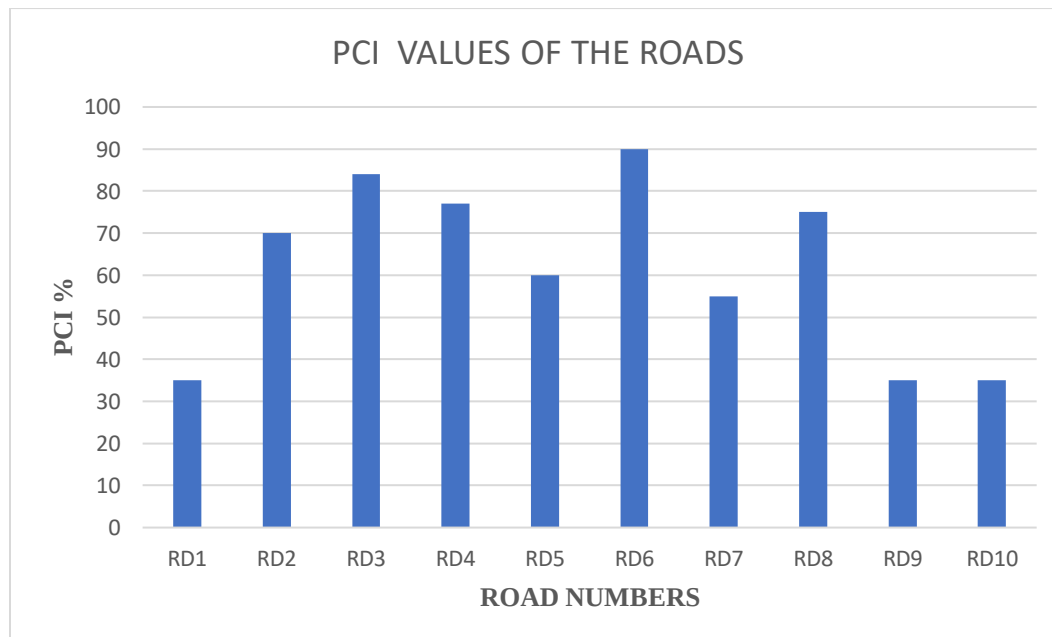


Figure 5: Bar chart showing the PCI values of roads studied

Appendix

Table A1: Campus Main Gate-Abuja Roundabout Road (RD1 and RD2)

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	Q	PCI	Rating
Delamination	8nos	L	0.1	20	129	65	6	35	Poor
Pothole	3nos	M	0.07	28					
Alligator crack	0.36m ²	L	0.01	4					
Alligator crack	120 m ²	M	2.8	32					
Block crack	603m ²	M	13.9	19					
Block crack	68 m ²	H	1.6	10					
Joint reflective joint	585	L	13	16					

Table A2: Campus Main Gate-Abuja Roundabout Road (RD2)

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	Q	PCI	Rating
Longitudinal crack	200 m	M	4.6	22	42	30	2	70	Good
Block crack	60 m ²	M	1.4	4					
Joint reflective joint	1170m	L	13	16					

Table A3: Abuja Roundabout-Engineering Road (RD3)

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	q	PCI	Remark
Alligator crack	2 m ²	M	0.1	7	29	16	3	84	Very Good
Block crack	230 m ²	L	5.8	6					
Edge crack	1170 m ²	L	29.3	14					
Lane drop-off	9m	M	0.23	2					

Table A4: Abuja Hostel - Chief Lecturers' Office Road (RD 4)

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	Q	PCI	Remark
Block crack	800 m ²	L	12.1	10	46	23	4	77	Very good
Block crack	1250 m ²	M	19	22					
Edge crack	240 m ²	L	3.6	6					
Longitudinal Crack	60m	M	0.9	8					

Table A5: Science Tech.-First Bank Road (RD 5)

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	Q	PCI	Rating
Block crack	1420 m ²	M	29	26	57	40	2	60	Good
Edge crack	1625 m ²	L	33	28					
Longitudinal Cracking	70m	L	1.43	3					

Table A6: Security Office-Digital Library Road

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	q	PCI	Rating
Edge cracking	600 m ²	L	23	14	14	10	1	90	Excellent

Table A7: Central Gen.- Abuja Roundabout Road

Distress Type	Extent	Severity	Density	Deduct Value	Total deduct value	Corrected deduct value	q	PCI	Remark
Joint Reflective cracking	500m	M	7.7	30					
Edge cracking	16 m ²	L	0.25	2					
Longitudinal cracking	200m	M	3.1	16	74	45	4	55	Fair
Block cracking	40 m ²	M	0.6	1					
Pothole	1no	L	0.02	5					
Depression	32 m ²	M	0.49	8					
Raveling	304 m ²	M	4.7	12					
LEFT CARRIAGEWAY									
Pothole	2nos	M	0.03	15	40	25	3	75	Very Good
Raveling	200 m ²	M	3.1	11					
Edge cracking	26 m ²	L	0.4	2					
Depression	17 m ²	M	0.26	8					
Rutting	12 m ²	M	0.05	4					

Table A8: Abuja Roundabout-Abuja Hostel Road

Distress Type	Extent	Severity	Density	Deduct value	Total deduct value	Corrected deduct value	q	PCI	Remark
Raveling	2380 m ²	M	100	44	90	65	2	35	Poor

Longitudinal Cracking	150	H	6.3	46					
Raveling	2380 m ²	M	100	44	90	65	2	35	Poor
Longitudinal Cracking	150	H	6.3	46					

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