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Research Article

OPTIMUM TECHNIQUES FOR ROAD PAVEMENT MAINTENANCE

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ABSTRACT
Infrastructure maintenance is essential for sustainable development as well as infrastructure development. A management system and road pavement maintenance that can be used as a decision making tool is required to road network maintenance. For this reason, most developing countries are looking for a system that can be most efficient pavement maintenance and management system to achieve the greatest economic returns from big budget which are spent in the road section. Roads in all countries represent anational asset and a large part of their annual development budget is spent on repair, maintenance and improvement of them. Therefore, use of a management and maintenance system which can be used as a tool for decision making and optimizing repair and maintenance costs is essential in road network. Develop a systematic and principled decision-making procedure to make basic decisions was always one of managers concerns. As a result of such a system, the possibility of applying personal tastes and opinions in the decision-making process denies and the reliability of accuracy of decision will increase. Due to the limitation of the annual budget for projects implementation, the priority projects have to be selected for implementation within the framework of budget limitation. Constraints and low quality of services in other modes of goods and passengers transport, as well as the use of personal automobiles, due to relative prosperity in trips has increased road travel demand so that respectively 80 and 90% of total goods and passengers transport in Iran are made by road transport which indicates the especial importance and role of roads in the current society economy life.

Keywords: *Road Pavement, Preventive Maintenance, Cost Efficiency*

INTRODUCTION
Road pavement maintenance management system is a tool for managers and experts to address to optimal pavement repair and maintenance decision making and reduce costs. Pavement maintenance management system is a part of an integrated maintenance management system of transport infrastructure. An integrated maintenance management system of transportation infrastructure includes maintenance management system of bridges, tunnels, ports etc. pavement maintenance management system could usually implement at two levels, project and network (Jafarpoor, 2002).
If road maintenance operations are performed at required time by selecting appropriate option for maintenance method in addition to delay their destruction, due to increased road surface quality, reduces vehicle operating costs and continuously openness of roads (Robinsn, 1998). The most important objectives of road management can be summarized as follows:
A. using organized approaches to make decision in an appropriate and identified framework.
B. Assessing roads conditions and determining the budget and resources required.
C. Selecting the appropriate standards for road maintenance and designing related activities.
D. Optimal allocation of resources and facilities.
E. Continuous review of policies, standards and the impact of activities.
Foreign studies show that increased investment for road infrastructure maintenance can bring many economic benefits. Simply stated, the allocation of $ 1 to roads maintenance reduces $ 3 of roads consumer's costs (Heggie, 1995). Hudson and Hass in "pavement management system" have defined pavement managements as follows:
It is a full and consistent combination of activities such as design, planning, construction, maintenance and repair, assessment, restoration and research on the pavement. Pavement management system implements at two levels, "project" and "network". Transposition, maintenance activities and the timing of projects in pavement management at network level is determined according to limitations, while at the

project level different methods of repair and maintenance for a specific project will be evaluated and compared (Haas, 1994).

Research Importance

Transportation system is one of the largest, most important and most sensitive government systems in all countries in the world. Management and efficiency of this system is very expensive and because of the direct relationship between it and the great mass of the people, is possessed of extraordinary sensitivity. So one of the fundamental concerns of all transport experts is to use an optimal way to reduce hardware costs and staffing costs, according to the sensitivities of safety, quality, etc. (Bagheri, 2005).

Creating a standardized information system with identified organizing, consisting the type, location, coordinates, physical condition and traffic equipment maintenance and repair requirements is one of the important steps in road transport system management to improve safety factor and optimize the cost of its maintenance and repair.

Road operation of vehicles forms the basis of road design and traffic analysis policies. The study on vehicles operations accomplishes two important tasks: First, it provides sufficient vision of road design and its traffic performance and the vision of necessary compromises to provide a wide range of vehicles. Second, it creates required middle way in design policies to obtain the effects of vehicle technologies development (Karimi, 2000).

Braking characteristics of a road vehicle is the only important aspect of vehicle performance from road design and traffic analysis point of view. Knowing braking behavior of the road vehicle is very important to determine the stopping distance, design road pavement and systems to prevent accidents. Pavement is a complex structure that is influenced by various combinations of environmental conditions and loading so its management requires a coordinated and systematic framework. Pavement management system (PMS) is an integrated method for maintaining approaches, setting priorities and the optimal time for repairs by predicting future pavement condition and also is a tool that helps managers achieve efficient economic policies for creation, evaluation and maintenance of pavements in good service condition. In a general definition the maintenance or toll is the operations during the operation of a road to maintain or improve the quality of its initial construction which follows three following objectives:

Reduce road failure and increasing its longevity.

Improve the quality of passing surface in order to reduce costs of vehicles depreciation.

Restore order and traffic safety for timely and safe arrival to the destination.

But in a more comprehensive look, road maintenance or toll needs engineering management as well as all of issues. An engineering management system (EMS) includes a set of engineering tools which are used to assess condition and predict it and develop working program with the aim of optimization. Therefore, in today's world that management science imported into all sciences and branches, toll shall be upgraded to the road management system. In this developmental processes, pavement management system has arisen as a coherent and systematic method to select repair and maintenance needs, set priorities and determine the optimal time for repairs by predicting future pavement condition (Bagheri, 2005).

Road transport is an essential component of economic development of the countries is and has always been a large part of the annual budget allocated to the countries. Experience has shown that there is a close relationship between the number of trips taken (km) and Gross National Product (GNP) of countries and in this respect road transport helps to economic development by making possible domestic and international trade and also creating employment and providing various services to the community. Convenient and fluent road transport only is possible with fine pavements and without significant failure which, as a result, reduces various costs, including the cost of raw materials production and can underlie economic health of a country and ultimately the community. In this regard, improving the riding quality of roads makes the number of moves made (trips) to be increased and economic growth to be developed. In developing countries enhancing the quality of road operation affect the speed of development in areas where the way passes cause employment and elimination of poverty (Karimi, 2000).

So the quality and quantity of roads and road transport infrastructure will have different effects on different aspects of human life. Increasing the number of travel not just reflects economic development

but it is also a factor so that today developed countries have the highest number of road trips. Roads repair and maintenance even in small amounts can result in many economic benefits. According to statistics provided, each dollar spent on the repair and maintenance of roads could save three dollars at the costs of road users (Karimi, 2000).

Research Objectives

1- Using a systematic approach to decision-making in the field of repair and maintenance pavements in a defined and targeted framework.
2- Assessment of financial and budget needs as well as the resources required for credit allocation.
3- Determining and recognizing minimum standards required for the maintenance of road pavements.

Geographic Information System Maintenance and Pavement

Based on research conducted in the world, about one percent of national production in developed countries is lost in road accidents and based on Dr. Ayati studies, this value in Iran is equal to 3% including 2% in road accidents and 1% in urban traffic accidents, also in this study 22% of accidents are associated with roads that 3 to 6 percent of road accidents are related to surface roughness and pavement failure.

Fuel consumption of vehicles depends on several factors, including the type, age, vehicle speed, the amount of stops and moves, tilt and overall path geometry and the type and condition of the road pavement. It should be said that above quantities are considered at pavement condition index (PCI) equal to 100 i.e. the best condition of pavement. Also fuel consumption of old automobiles are calculated on average, 20% more than new automobiles. By increasing the road roughness and reducing the amount of PCI, fuel consumption of automobile is increased that this increment can be summarized in the following table for the worst pavements, PCI=10, to the best pavement, PCI= 100:

Table 1: The average fuel consumption of cars in suburban roads (liters per hundred kilometers)

PCI Operation speed Kph	10	20	30	40	50	60	70	80	90	100
60	125.4	118.8	112.2	105.6	99	92.4	85.8	79.2	72.6	66
90	159.6	151.2	142.8	134.4	126	117.6	109.2	100.8	92.4	84
120	205.2	194.4	183.6	172.8	163	151.2	140.4	129.6	118.8	108

Above statistics represent a 90 percent increase in fuel costs at an ideal pavement compared to pavements in the worst conditions. Fuel consumption in trucks with an average speed of 70 km per hour is 35 liters of gasoline per 100 km which can be changed by changes in road pavement as follows:

Table 2: The consumption of diesel trucks on suburban roads (liters per hundred kilometers)

100	90	80	70	60	50	40	30	20	10	PCI
289	310	330	350	370	390	410	430	450	470	Fuel consumption

Undoubtedly the roughness of the road has a significant impact on the increase in erosion of tires. Moves with numerous stops increase erosion of tires up to 7-times.

If the cost of tires at a speed of 90 km per hour in the ideal pavements have considered as 1000 the costs will be as follows:

Table 3: Increasing erosion of tires

100	90	80	70	60	50	40	30	20	10	PCI speed
1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	90

Now, there are 220,000 kilometers of primary, secondary and rural roads in the country that the current value is estimated at about 200,000 million Tomans. The importance of this massive national capital becomes more and more apparent due to budget constraints in recent years, because after years of development land roads, now its turn to their maintenance and optimal utilization of them. Most worlds' industrialized countries that have expanded or completed their communication roads network have put maintenance operations as the preferred approach. Repair, maintenance and improvement of roads, has very high costs and these costs must be spent in the desired time efficiently and economically otherwise, repair and improvement operations will be unjustified. According to a general statistics of Ministry of Road, the budget needed to ideal maintain of roads is equal to 8 thousand billion Tomans per year and the allocated budget in the current year have been considered as 1000 billion Tomans. This demands the necessity of paying more attention to economic and technical studies, prioritization and scheduling for repair and timely maintenance (AASHTO, 2002).

To manage and maintain pavements at an acceptable level and quality, a management support system is needed. A set with the size of the country's roads and its massive data volume can be managed when sufficient data from all regions and all aspects of work is available. The support system that could cover all the data and combine them in an integrated set, between the various systems available, due to the dependence of civil engineering especially road construction and toll the spatial information, the GIS has been chosen as support system. An efficient geographic information system provides a suitable platform for all the details and plugs that can be monitored by PMS, the results of GIS / PMS is a strong tool for improving all PMS components and parts. So create and setting up a suburban pavement management system and use of geographic information system capabilities in it can optimize and set time of repairs and also reduce costs.

In suburban roads and urban facilities a percentage of drivers can usually drive near the free speed of traffic governed by geometric elements designed. Therefore, choosing the right design speed of is practically important. Despite the appropriate choice of designed speed, movement speed and practical speed often is contrary to designed speed and causes accidents in urban and suburban roads. It is therefore necessary to implement actions to keep movement speed far from designed speed and close cars speeds to expected speed as possible. Accordingly, various strategies used to control and limit the driving speed. This type of control could be applied by the driver, the vehicle or road. Driver's violation and individual fault can be a deterrent to this speed control. On the other hand, facilities in your vehicle is a factor in increasing the speed and deviate from the safe speed easily. The only factor that can control and manage the car speed without the intervention of the driver is the road and the road geometry. In the present paper, the methods of control and reduce the speed of cars using the geometric elements will be studied.

Maintaining Roads is an Effective Way to Economic Progress

Building roads is a fundamental and infrastructure aspect in economic development programs. Constructing a string of roads which link a number of cities and economic regions together creates a profound economic change in all these areas and converts their closed economy to an open and fruitful economy. In the economic history of our country much have been said about the great importance of the large highway that had linked East and West, North and south of the country and these important economic and social works have been discussed in detail. Also in the history of economic developments in Europe study on the Role of sea and land ways in the economy progress of there and broaden the scope of the market and thus enhancing business boom is important. In economic books written about economic growth and development, the impacts of well-equipped roads on economic and social development and facilitate the implementation of various development programs all discussed in detail. In operation it is shown that the origin of many economic development programs is also road construction, and build a right road is considered alongside a great development plan. As in the case of steel plant construction in our country along with the original plan, constructing Kerman - Isfahan railway and other roads have been considered (Yazdi, 2005).

Fortunately, in economic development programs which have been implemented in our country road construction has its own proper place, as about ten billion Rials were considered for building secondary

roads in third development program and other high costs were spent on building highways and primary roads that in practice the construction and repair of each these roads has revealed positive impacts no needs to discuss and prolongation word. Here's a hint to the point that the constructing roads in economic development programs is an issue and maintenance of roads is another thing that has the importance equivalent to the construction of them. As far as can be seen in practice in our country more attention has been paid to the first issue and to the second issue which is maintain roads built not only is not paid attention but also it can be said that is highly ignored (Austroads, 2002).

There are many roads that have been built with high cost and time and bear any problems, but these roads due to landslides, bridges breaking down, removal of asphalt etc. become disabled or the use of them becomes very difficult. Such a situation apart from wasting costs spent such as car and tire depreciation and delay transport goods and many other factors indirectly brings losses for our economy. To avoid this predicament and harmful situation, it is necessary that after the construction of each primary and secondary road an equipped organization has established especially and for the maintenance of the road, and its credit predict and be adopted with the main program at the same time. Establishing such organization especially now that construction of secondary roads becomes more widespread and rural areas have been linked by these roads should be further considered. The maintenance of the roads, especially in terms of the approach of severe economic programs that enable more connection in different regions of our country and causes more traffic and transportation is much more important. Industrial units across the country need to market and the products of these units should be absorbed in the domestic market. Previously as a result of agricultural dominated decadent system, farmers were poor and their purchasing power was low and therefore they were not able to buy industrial products, but today with the implementation of the land reform program income and purchasing power of our farmers have risen and every year their income and purchasing power increases. Higher income enables the farmer to purchase industrial products.

On the other hand many industrial units will establish in the coming years, which need to market and the largest market for these units are rural areas. So paying attention to consumer demands of farmers as well as expansion of markets and facilitate and development of industrial units requires that apart from design a broad and long-term plan to building roads maintenance program also be considered. Because if our country roads do not develop consistent with the industrial economic and agricultural development progress in the future there will be big problems for the economy of our country (Federal Highway Administration, 1999).

Road Maintenance and Management System

Pavement Maintenance Management System (PMMS) is an interconnected combination of activities including operations, procedures, data, software, strategies, and decisions on the road pavement maintenance management that manages implementation of all activities related to the management of pavement maintenance. This system is the first system which was introduced in the field of road and transport infrastructure in the world. Then other systems have developed. Pavement Maintenance Management System includes following general activities (Hudson, 2000):

• definition of pavement network
• Assessment of the pavement
• Management in the network level
• management in the project level

Road Maintenance and Management System as a Subset of Infrastructure Integrated Maintenance Management System

Transportation infrastructure means physical facilities which provides basic public services for road users. Bridges, roads pavements, airports and ports, are such transport infrastructure. Usually, large organizations have different types of infrastructure management systems, such as management system of bridge, pavements, etc. some problems and lack of coordination between these systems, has led experts to use a coordinate set of infrastructure management systems. The integrated system is a structured approach to help infrastructure efficient organizing (OECD, 2000).

In the integrated system, where all systems are considered as subsystems, there is an integrated database to correct management decisions. This eliminates duplication and incoherence of the system.
Study on the integrated maintenance management system infrastructure process how's that the implementation of this system in the world is generally done in two following ways:
• Implementation of infrastructure maintenance management systems separately and then integrate them.
• Full implementation of the integrated infrastructure maintenance management system at the same time with needed subsystems.
In the first case some infrastructure management systems operate integrated by equalization databases and financial resources to state etc. It should be noted that some organizations enforced, at least some infrastructure management systems to integrate. For example, the US federal government is considered essential the following subsystems to create an integrated infrastructure in the first place (Austroads, 2002).
1- pavement, 2- bridge, 3- safety, 4- density (congestion), 5- public transport, 6- communication roads
For the second case (which is very comprehensive and ambitious, perhaps) can mention to integrated infrastructure management system that was implemented in Kuwait. The structure of this system has been presented in figure 1. It should be pointed out that there is no single infrastructure management system that is ideal for all organizations and every organization has a unique situation in accordance with its specific needs.
Generally, to make and develop an integrated infrastructure management system all decision support systems should be carefully integrated. Each organization must determine short-term and long-term goals for infrastructure management system. If integrating various systems is a long-term plan, the structure of each these management systems should be such that it can establish the relation between these systems in next steps with minimal resistance and difficulty (Smadi, 2000).

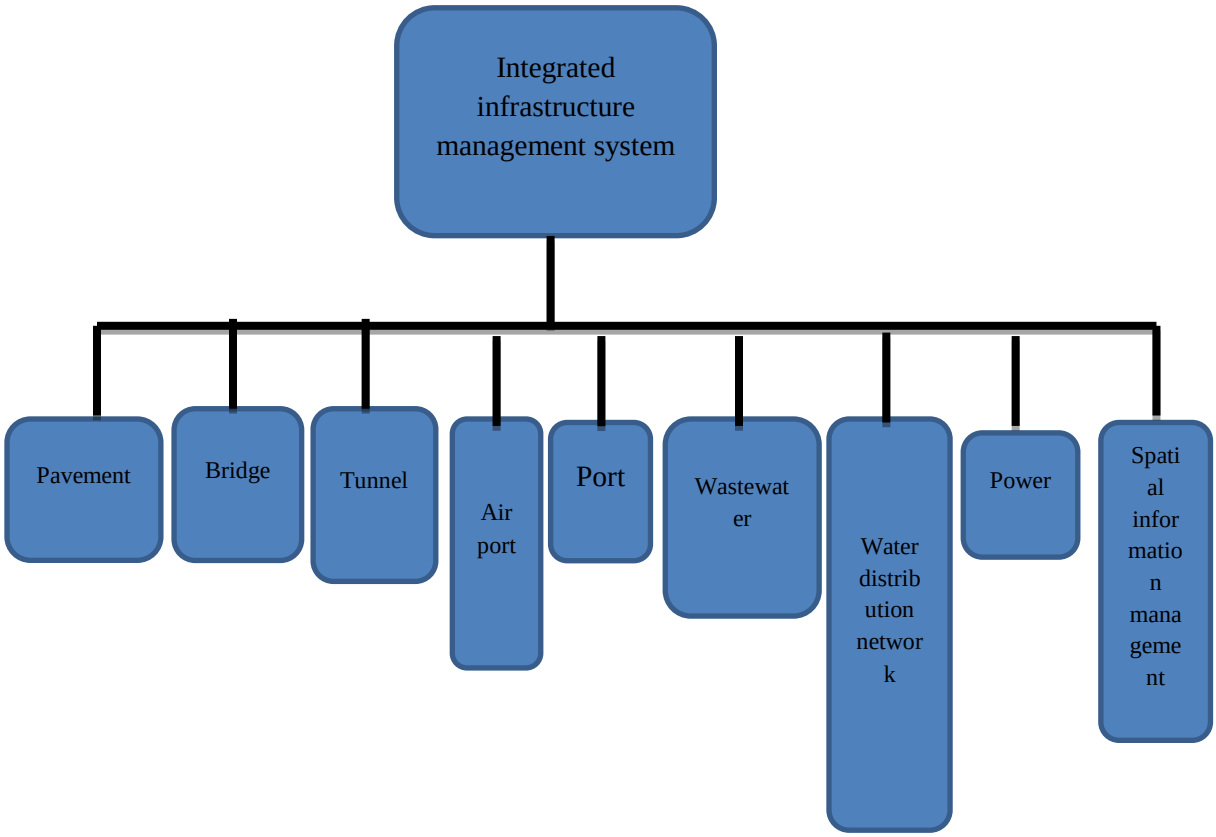

Figure 1: Structure of integrated infrastructure management system of Kuwait Network and project levels in pavement maintenance management system

Pavement management is a process which has two main operational levels: the network level and project level (figure 2). Management in network level performs development, prioritizing and scheduling tasks, taking into account limitations related to the budget and on this basis, activities is done in the project at the right time.

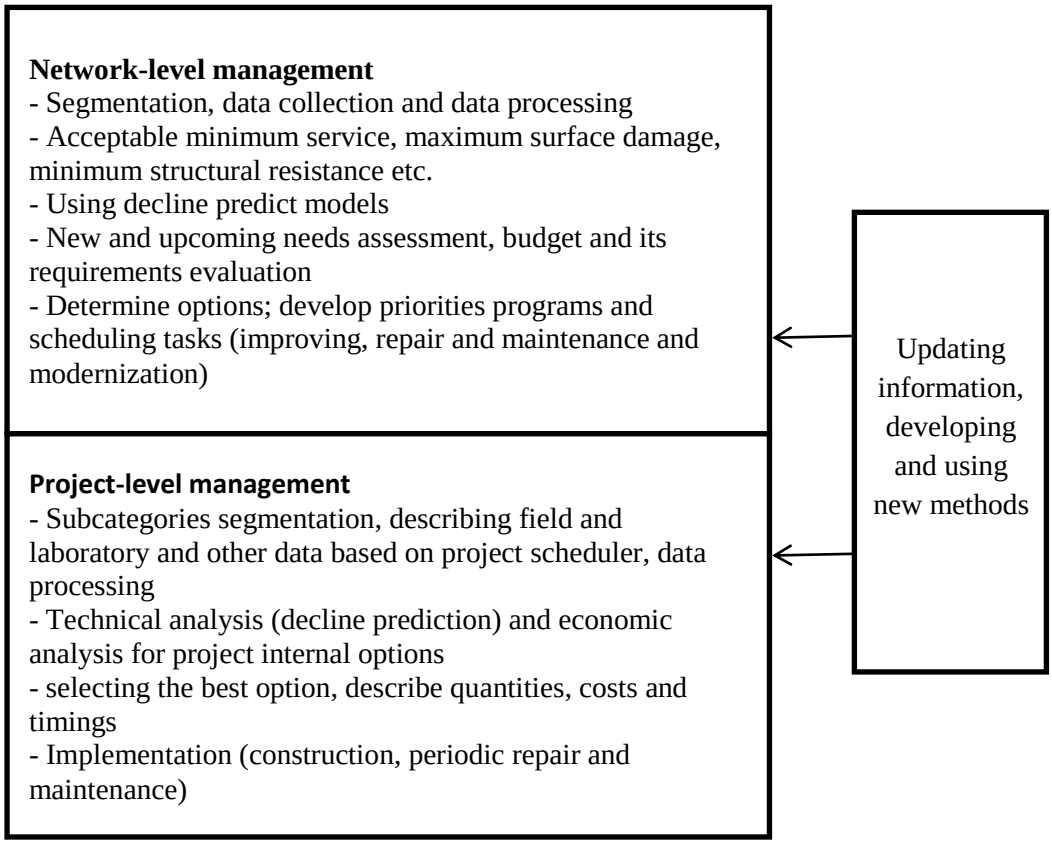

Figure 2: The main operating levels of pavement management and its main implementation

MATERIALS AND METHODS

Methodology

Management and maintenance of traffic equipment in the first place need to choose a suitable application method. This method should include an appropriate method for the purpose of maintenance model, collecting information required. In this study, the performance index model which works based on rating homogeneous elements in the process of maintenance and repair have been used. At first the model parameters is selected among the multiple factors involved in the management and maintenance of traffic equipment. After selecting performance index model and determine the performance index, the appropriate method to collect information required to each indicators should be developed. After developing the data collection method and record it in a data base designed, according to the needs of the system, specialists do appropriate actions for specific situation to perform their duties n the maintenance and repair of equipment (Smith, 1997).

RESULTS AND DISCUSSION

Recommendations

- Coordinate method can be used instead of kinematic method and recommended that take peer review on answers in two computing engines other solutions used to calibrate the data interpretation.

- Creative and innovative research method can be used. In this data group, criteria such as risk and performance index or minimum time or a combination of these can be analyzed.
- Using image processing and artificial intelligence to reduce the role of the human user, and increase accuracy is also recommended.
- Investigating several optimization methods for finding the shortest path to reach the equipment that needs to be repaired. This reduces the cost and time to access damaged equipment.
- Find a rate of damage types and the determination of inventory that will help to raise the level of service.
- Determine the number of required staff and expertise's based on the results of this study lead to an increase in the level of service

Epilogue

Roadsinall countries represent a national asset which high costs spend on repair, maintenance and improvement of them annually. On the other hand the lack of proper attention to the issue of road maintenance increases failures and maintenance costs, so presenting a system for roads repair and maintenance can be effective in reducing costs. In our country the use of traditional methods and failure to provide a comprehensive and clear plan for roads pavement maintenance creates many problems for roads pavements including short life time of pavements comparing to international standards, inappropriate roads pavement condition, inflicting high costs and material losses to the country. Considering that in most developed countries many of these problems have been reduced by creating and implementing pavement management system and many developing countries have also be able to localization of the system for their country greatly reduce the problems of roads, so the implement a system in our country seems necessary. Hence, we can use the talents and scientific and implementation abilities of the country and using the experiences of other successful countries in this area this matter can be achieved.

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