



## Innovation in Road Construction Industry: An Analysis of Different Case Studies

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### ABSTRACT

Process improvement and innovation in the field of road construction sector offers significant community and industry benefits, by making an important contribution in economic growth and enhancing the quality of life. However, achieving better innovative practices in order to improve existing construction processes and to heighten competitiveness have gradually become a challenge for the road industry. The use of innovation in this context refers to the use of suitable materials in the construction of road, material such as eco-friendly roads, solar roads and recycled materials. This paper examines 12 different case studies on the uses of new material in road construction and where case studies are from different countries in different context and explores the usefulness of the practices under numerous road situation and conditions. The case studies have been analyzed in the following context: location of the case study, which helps to identify the suitability of road construction material with the weather condition; driving factors, which indicates, how and what selected case studies contribute in the field of innovation; economy and environment feasibility; and barriers in the case studies, which indicates hurdles to implement selected case studies. The study findings indicate that in order to maintain competitiveness, construction industry needs to continuously focus on the improvement of their construction processes and innovative materials. Finding indicates that in most case studies both economic and environmental benefits were realized.

**Keywords:** Construction innovation; Manufacturing innovation; Road construction; Case study; Project management; Plastic bags; Glass bottle

### 1 INTRODUCTION

It is widely accepted that innovation is required in the road construction industry as a foundation to competitive benefit for organizations functioning in the road construction industry. However, there is a perception amongst some specialists that the process of innovation in construction industry is uncommon and that the construction industry is slow to change. This type of perception occasionally arises from contrasts of road construction industry to the medical, education, electronics and other business industries in which the implementation and adoption of new theories, products and technologies have been widespread over the past numerous decades (Drejer, 2002).

Despite this opinion, the idea of innovation in road construction industry does occur and the idea has been documented by many developers and researchers (Slaughter, 1998), hence there is continued attention in shaping how to improve innovation in the industry. Panuwatwanich, Stewart, & Mohamed (2009) suggested that the process of innovation in road construction industry is necessary as a foundation of competitive benefit for similar organizations. Aouad, Ozorhon and Abbott (2010) underlined that the competitiveness of organization unavoidably based on regional and national arrangements of innovation in the construction industry, which in alternately depends on government procedures and policies. Consequently, given the continuous and rapid changes and enthusiasm of the commercial environment, protecting competitiveness is thus an important agenda of most organizations in construction industry.

Many researchers have identified that rise in technical knowledge of innovation in the road industry in relation to the road material and road, the growing exchange of information between different developing and developed countries across the globe offer new options and possibilities for the asphalt roadway societies to support the wider realization of innovative service or products used in all designated nations to achieve a practical and cost-effective optimization of road supervision and administration (Lundberg, et al., 2019; Caerteling, et al., 2011; Hausman, 2005; Wolfe, 1994).

This paper examines twelve different cases in context of innovation in roads which include, use of recycled material in road construction industry, development of eco-friendly roads, solar roads, Tron-like and glows in the dark, use of technology in traffic control, precast pre-stressed concrete pavement, toner recycling for roads, extracting energy from roads, foamed bitumen stabilized pavement and use of plastic in road construction.

## **2 INNOVATION IN ROAD SECTOR: CASE STUDIES AND DISCUSSION**

The aim of this paper is to examine different road situations, where innovation has been implemented. The case studies are presented below. Twelve different case studied from different countries are presented.

### **2.1 Use of recycling material in road industry**

In Hamburg, Germany, new policies and procedures have been executed stating that the Hamburg road required to be use recycled materials only. Similarly, there has been a noteworthy growth in the cost of road materials, which were used for the building of bridges and roads, including aggregates and bitumen. Therefore, the management of Hamburg City has involved road construction corporations to carry out development and research to deliver a justifiable solution to supply for the requirements of the new procedure policy, as well as to manage the problems related to the price increment of materials used in road and bridge construction. As a result, an explanation was provided to construct 100 % recycled asphalt pavement (RAP). This solution not only helps to consume fewer energy, but it also minimizes the harmful emissions of gases for example carbon dioxide gas emission. In this context Bitumen is one of the most expensive road materials, which is used for the development of special roads and bridges. Though a meagre 5% of the road material structure is bitumen, this could donate to 60% of development cost of road and bridge. Likewise, bitumen product is an oil based road

product that could not be locally obtained, addition to the high price instability of the road material (Schroeder, 2015).

In San Francisco, Bay Bridge was demolished due to the earthquake in 1989 and the bridge rebuilding started in 2002, where all recycling materials were used. The rebuilding of bridge took benefit of applying the exclusive properties of ash along with the ground ash generated by the explosion furnaces in regard to improve the strength along with the sturdiness of the road material such as concrete and which used in rebuilding the bridge. This project applied the biochemical properties of ash concrete in regard to uncover the undesirable accoutrements of the sea salt fog and water which has harsh action, as the mechanical demand of the zone of earthquake. The bridge zone, which an immense salt content is made through applying a concrete mixture that comprises 50% fly ash. This leads to the inhibition of bridge cracking afterward the toughening of the cement used in the bridge. The technique is commonly used in the areas where the salty water is commonly found. Moreover, the uses of particles from the fly ash could leads to the enhancement in the mixture usefulness and durability; also the fly ash uses could makes the mixture thicker and stronger as compare to the old-style concrete which used in the old age, making it improved equipped to transmit substantial traffic loads. However, more than 30 concrete mixes designs have been applied for the building of the new bridge, in which more than 50% mixes were from the fly ash. The process of bridge construction also applied slag, which was crushed, granulated from the explosion furnace. This slag was applied in the pier column, which in result the bridge durability and workability improved substantially (Schroeder, 2015).

## **2.2 First road developed from plastic bags and glass bottles in Australia**

In Australia, the city council Downer, Hume and sustainability, Melbourne Victoria both are working with the RED group to do research on building suitable road, which is made of plastic bags and glass (Onkaparinganow, 2018; Department of the Environment and Energy, Australian Government, 2019).

Through associations with clients, the larger industry and other suppliers, Downer council is including better-recycled content in roadway, while attaining lesser greenhouse gas footprint. This research is not only good help the country to control waste, but also helps to develop roads, which are suitable for the environment. The City of Onkaparinga in South Australian (SA) build a first road from plastic bags and glass in the Happy Valley. The council used about 139,000 plastic bags and 39,750 glass of bottles equals diverted from landfill, as shown in figure below (Onkaparinganow, 2018; Department of the Environment and Energy, Australian Government, 2019). The material used in the road is ethylene-vinyl acetate (PEVA) and glass of bottles, where packaging, of 63,000 glass bottles and soft plastics from roughly 200,000 plastic bags have been obtained.



Figure 1 : Road developed from plastic bags and glass bottles in Australia (Onkaparinganow, 2018; Department of the Environment and Energy, Australian Government, 2019)

### **2.3 The innovative in eco-friendly road solution**

In Israel, roads of Haifa and Ra'anana are two different examples of the extemporary use of innovation in road to generate electricity and for collecting the waste-kinetic energy. An Israel firm which is privately owned has formed customized piezotech generators which could be used for the wasted kinetic energy in building roads/bridges and convert it into electrical energy. This technology is being applied in road construction because the kinetic energy that is converted into electrical energy is collected and applied for road signaling systems and lighting the roads. It is also applied for lighting the diodes which produce lights (Probst et al., 2013).

This form of innovation has given numerous benefits to the road building system. This has led to the sole reliance of development of roads based from the parasitic power, as the movement of road traffic on highways generates kinetic energy that is collected in the shape of electrical energy. They give a continuous supply of electrical energy to the bridges and roads regardless of the weather conditions. This is a method of electrical energy to the roads and bridges, which is recognized against any damage and theft. This method has led to the construction of smart and reliable roads in the region, heading to self-competence of bridges and roads, consequently preservation of power also is made feasible (Probst, et al., 2013).

### **2.4 Solar roads**

Many countries around the globe these days are using solar panels, which are organized consecutively and are planned architecturally to drive cars upon the road. These are innovative and revolutionary replacements to the infrastructures, which are, construct of petroleum bi-products and asphalt. Likewise, to support green communities, it is a good alternative as it useful to use fossil fuel to produce energy. The idea of solar roads is to store the energy and then energy can convert into the form of electrical energy. The energy produced could be applied to bright the roads and bridges along with generate power for the local homes and the business. The key breakthrough of this development is the solar panel, which could stores power.

In this context, Netherlands is the first country, where they introduced a bike lane

based on the solar. The path along the road where they installed solar is in Amsterdam with the suburban zones of Wormerveer and Krommenie. This is the first solar path along with road that allocate to bikes only and which harvests power and is paved. The council put this project on trial for six months and result after six months indicates that the solar road system improved performances in context of operational cost and usability of the road.

Moreover, this solar path able to produce about 3,000 kWh electrical energy, that is adequate to brighten a single house for at least year. The Spokesman of this project “Sten-de-Wit” said. ‘if the yearly yield of the solar path is decoded, it could produce about 70 kWh meter of electricity every year.’ The concept of developing solar paths on side of the roads became very widespread and now The United States of America planning to install solar panels on their all roads and highways (Katharine, 2014). The solar road produce energy, which cost \$20 per kilowatt-hour, which is around 13 times higher than the traditional method that cost only \$1.53.

## **2.5 Tron-like and glows in the dark**

In the country of Netherlands, roads and bridges development has come another innovatory invention. It is constructing a highway that glows in the dark and is Tron-like, considered being the world’s first highway which glows in the dark. Netherlands announced they already started this research project and now they are in the testing phase and this about 500 meters of the N329 Oss freeway that have been prepared for this innovative idea implementation. These roads will not only glow in the dark but also will give weather indications. They named that as a “Smart Highway” and the concept behind this development is the construction of freeways which are sustainable in nature and interactive. These freeways will be painted in a way that could glow without any light, through captivating energy during day time and they estimated paints glow could glow for eight hours (Dube, 2014).

The execution of this research could be an efficient initiative to preserve, very smart in saving cost and energy, as, if this research becomes successful, country could change the local road and streetlights also. These innovative freeways will lead to the formation of safe and maintainable roads. According to Heijman, this technology could be an alternative of the lighting posts, which are located alongside the roads of the freeways. Similarly, this development could serve as an improved substitute to roads in the zones where electricity and lighting do not exist (Dube, 2014).

## **2.6 Use of technology in traffic control**

In Sydney, Australia, the Coordinated Adaptive Traffic System known as SCATS has been controlling Sydney traffic effectively. This method has become globally acknowledged, and is being applied in more than 141 cities in different countries around the globe and the method is regulating 32,000 road connections in the world. SCATS has recognized itself widespread and internationally accepted technological systems in order to control traffic. The National ICT Australia (NICTA) is the Center for development and Research in ICT Australia, which was developed in 2004. The NICTA has delivered an innovative solution, which has been well established and successful in the context of controlling traffic. The research group actively involved in discovery innovative

approaches of traffic control on different road situations (Kilby & Johnson, 2010).

### **2.7 Precast Pre-Stressed Concrete Pavement**

From last several years, the United States State Transportation has been working on how to adopt innovative approaches and using systems of road building so that normal traffic flow cannot be disturb. In this context PPCP know as Precast Pre-Stressed Concrete Pavement brought another innovative idea, in which an effective and durable road can be developed without distracting the normal traffic flow. In Texas University, a Center for Transportation Research (CTR) conducted a study on roads feasibilities and result revealed that there was a developed of 0.7 Km of the PPCP pilot plan. This pilot plan was later conducted nearby Georgetown, Texas ( U.S. Department of Transportation, 2015; Merritt & Tayabji, 2009).

By means of formed concrete pavement includes the use of advanced methods for road building in regard to build and repair roads and bridges in less period of time. The modules that are assembled and invented anywhere else and afterword transported to the production site and connected. This method is highly reliable, as it involves short time frame for field preserving. This research could be applied effectively for road repair in shorter time frame and its rebuilding and for high traffic situations. Currently, the research is applied for continuous intermittent repairs and rehabilitation (Merritt & Tayabji, 2009; U.S. Department of Transportation: Federal Highway Administration, 2015).

An additional research project was commenced at the center of Caltrans, which was supported by the PPCP system by means of spreading of the worryingly trafficked lanes. The project resulted in addition of 10 feet and 27 feet lane with the existing lane. The key advantage of these pavements in this research project is to improve the road quality and minimize the road development time (Merritt & Tayabji, 2009; Department of Transportation U.S., 2015).

### **2.8 The Jet Stream Super-Highway**

The innovative concept of super highways is based on the automobiles which extract power from the structure of the bridge or roads and take power from the situation (Huang, 2015). These freeways or highways have been designed in a way where wind in the tunnels that lead to the creation of a stream of airflow on a constant basis. The design and shape of these types of roadway is like a half-pipe see through in a cross-sectional sight. These freeways are made up of a sequence of turbines which are motorized by solar electric and road hover in regard to push the airflow in the road trail. Moreover, there is a cycle impact formed by the sketching vents over the sides as a result of airflow being drawn endlessly. Due to the solar panels coating at the upper surface of the road, makes it a very atmosphere friendly. There are electronic sensors that permit communication with the automobiles which are driven on the road, in regard to obtain precise adjustments. This freeway is founded on the idea that the future of the transport in urban zones is based on applying green systems of energy practice along with conservation (Huang, 2015).

### **2.9 EME2 technology and high modulus Asphalt EME2 Pavement Design**

The road construction industry is facing challenges to the design and delivery of high-performance asphaltic concrete in order to carry high traffic load including axle

wheels loading. As the density of traffic is increasing in Australia day by day, there has ascended a requirement for a reliable asphalt materials in regard to manage the changing weather conditions. The EME stand for ‘enrobes à module élevé’ and it is a French word, which is also known as “high-modulus”. This technology is being applied widely in the country of France, where it the technology was originated. The technology of EME is divided into two grades, namely: EME Class 1 and EME Class 2.

The difference among these two grades is that the EME Class 1 include higher binder content in the material in context of richness modulus; the EME2 mixtures are founded on richness modulus along with the requirements for features like water sensitivity, stiffness, wheel tracking, and fatigues. The EME class 2 is usually applied on roads where traffic load is high. The key features of EME are that it is moderately stronger as well as rigid. Also, reduces the pavement thickness without major any big change in the roads strength (Petho & Bryant, 2015; Petho, Beecroft, Griffin & Denneman, 2014). Moreover, central laboratory and Colas’ in Paris, both companies have been able to evaluate the mix designs by using Strain Alleviating Membrane Interlayer (SAMI) bitumen and local aggregates to guarantee that the proposed mix design should fulfil the France requirements.

### 2.10 Foamed asphalt stabilized roadways

An initiative of the Austroads (Australia) since 2012 is testing the Foamed Bitumen Stabilized Pavement (Rose & Manley, 2012). The objectives of Arena Evaluation of Foamed-Bitumen-Stabilized-Pavements are: 1) development of the measures for Austroads in regards to the design of new materials for roads, and the roadway of structural reintegration and handling of the Australia roads; 2) identification and examination of the modes of distress of the FBS roadways; 3) development as well as coordination of the nation-wide mixes design for Foamed-Bitumen-Stabilized materials.



Figure 2: Twelve case studies from different countries

## 2.11 Plastic roads

The Netherlands is a country where some developer is doing a pilot study on the construction of new types of road, which is easy to construct and much more reliable, using recycled plastic. (Koudstaal & Jorritsma, 2015). They will bear higher variation of temperature and need comparatively fewer maintenance. The data that is collected from numerous real-world case studies from different countries as shown in figure 2. Moreover, these case studies have been analyzed in the context of demonstrated drivers, economic benefits, environmental/sustainability benefits and barriers to innovation for each case.

## 3 CONCLUSION

It is widely accepted that Government agencies in the road construction and management industry sector aim to achieve value for their investment as they procure road construction industry services. As Government announces any road construction project and seeks procurement for services, several contractors apply, and it is complex to assess innovation in these proposals on a comparative basis. This requires several factors such as: clear project definition, what is new (innovation), previous experience for the proposed project. However, it is not easy to assess innovation on a comparative tender assessment basis.

The aim of this paper is to analyze different case studies in the context of innovation in the road construction industry.

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