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EDITOR

Sam Enmon

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Volume 10, Summer 2016: IRF Student Essay Laureates
Volume 11, Fall 2016: Smart Highways
Volume 12, Winter 2017: Value Engineering
The wealth of knowledge accumulated during the 17th IRF World Meeting & Exhibition in Riyadh was the driving force behind our decision to launch the IRF Examiner as a freely available resource for the industry. With this tenth issue, the International Road Federation confirms its role as a leading provider of applied knowledge in areas of vital importance for the global community of road professionals.

As the road sector delivers increasingly sophisticated solutions addressing our societies new mobility needs, the availability of global knowledge resources such as those provided by IRF is now more important than ever. I invite you to make full use of these resources and the associated training programs delivered by IRF.

H.E. Eng. Abdullah A. Al-Mogbel
IRF Chairman

Roads are the world’s first “social network”. They are fundamental building blocks for human and economic development whose impacts transcend national borders. The benefits of investments in roads have shown how transformative an infrastructure they can be for a wide range of beneficiary communities. At the International Road Federation, we have tried to capture these connections with a simple slogan “Better Roads. Better World”. Since we were established 1948, our primary purpose has been to transfer the latest technologies and knowledge from those who have it to those who need it, and in doing so, promote an agenda of shared prosperity that flows from accessible, affordable and sustainable road networks. The IRF Examiner is an essential vehicle to this ambitious agenda.

C. Patrick Sankey
IRF President & CEO

Governments across the Middle East & North Africa are under extreme pressure to deliver adequate transport infrastructure and services to their populations in a context of rapid urbanization and growing vehicle ownership. Confronted with these challenges, transportation leaders across the region are investing in a range of new infrastructure programs and services, as evidenced by the emergence of spectacular highway and mass transit projects. But the work conducted by the region’s academic community in understanding these challenges and identifying original solutions is equally important. For this issue of the IRF Examiner, we have selected papers from the region’s foremost subject matter specialists, all drawn from the scientific proceedings of the IRF Middle East & North Africa Regional Congress held in Dubai in 2017.

To build on this foundation and continue advocating for long term investments in infrastructure and human skills, we are forming a regional affairs committee open to all IRF Members. Our goals are to assist participating organizations gain access to a wider pool of knowledge on regional infrastructure programs, and solutions designed to optimize road investments. This goal is achieved through a regular flow of information on programs of shared interest, and by steering regional IRF policy and capacity-building initiatives on priority topics, including but not limited to, traffic safety, road design & construction, asset management, ITS, resilient infrastructure, and financing solutions. On behalf of the IRF, I would like to invite you to join us for this important task.

Shafik Nasser
Chairman of the IRF Committee for MENA and GCC
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APPLICATION OF SUSTAINABLE PAVEMENT CONCEPTS IN DESIGN AND REHABILITATION OF ABU DHABI ROAD PROJECTS

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ABSTRACT
As the vision of Abu Dhabi Government is to achieve social development in a sustainable manner, the implementation of sustainability concepts is a major objective for Municipality of Abu Dhabi City (ADM). Project performance, life cycle cost, the use of recycled materials and energy saving are major considerations in ADM sustainable pavement design.

The first application is the use of geo-grid in sustainable pavement design. In this case study the geo-grid is used for reinforcement of granular base course or subbase.

The second application is utilizing cold in-situ pavement recycling in rehabilitation of life ended asphalt pavement. The main objective of this application is to utilize the recycled pavement material by adding foamed bitumen to extend pavement service life and reduce construction cost.

The third application is the use of polymer modified bitumen in construction of intersections at Mussafah industrial area, Abu Dhabi. The main target of this application is to have more durable asphalt pavement at intersections of industrial areas.

SUSTAINABLE PAVEMENT DESIGN UTILIZING GEO-GRIDS

Design Approach
The ADM team has followed the following steps to review pavement design, utilizing geo-grid material as reinforcement for road base course and road subbase (2):
- Technical review of material properties and previous implementation
- Verification of material properties
- Review of pavement design criteria (1)
- Review of the derivation methodology of design parameters, expressing contribution of geo-grid material in overall pavement structural number (6, 13, 14)
- Review of the independent report addressing the review of design criteria and design parameters
• Conducting AASHTO layered analysis to check minimum required layer thickness based on the value of resilient modulus
• Considering existing and future utility lines and expected future maintenance of road and infrastructures with existence of geo-grids
• Evaluate design options by assessing the expected service life calculating life cycle cost and carbon emissions respectively

Case Study #1 Pavement Design of Industrial Project – Main Road
This road was designed at 2011 as a main road at industrial area in Abu Dhabi to serve about 134,000,000 ESALS. The implementation of geo-grid material in pavement design resulted in significant benefits for the project as:

• Enhancement of granular base course performance and reduction of pavement thickness
• Savings of about 17% of pavement cost
• Carbon foot print reduction of about 15%

Case Study #2 Pavement Design of Residential - Commercial Project
This road was designed in 2014, as an urban arterial road at residential - commercial area in Abu Dhabi, to serve about 28,000,000 ESALS. The implementation of geo-grid material in pavement design resulted in significant benefits for the project as:

• Enhancement of granular base course performance and reduction of pavement thickness
• Cost saving of about 14% of pavement cost
• Carbon foot print reduction of about 18%

Findings and Achievements
ADM case studies showed several technical achievements including enhanced mechanical characteristics of reinforced road base materials providing longer service life, reducing pavement thickness, a reduction in pavement distresses and reducing the risks related to construction quality.

A reduction of pavement construction and life cycle costs of about 15% was achieved by Abu Dhabi projects ($120 million AED). A reduction of construction time of about 12% and saving in energy consumption during construction was realized.

The reduction of the use of raw materials was roughly 15%. Also reducing carbon emissions, air and noise pollution during construction resulting in lower impact on public health.

THE USE OF COLD IN-PLACE RECYCLING IN SUSTAINABLE PAVEMENT REHABILITATION
A pilot project study was conducted in 2011 to study cold in-place recycling as a design option compared with conventional pavement rehabilitation by removal and reconstruction of Road Number (31/16) in Shahama
area as a part of the project Study, Evaluation, Design & Supervision of Road Maintenance & Rehabilitation Works of Abu Dhabi Main island – North.

Deep block cracking and asphalt hardening were both observed. It was concluded to remove 15 cm of asphalt, then check the existing road subbase and finally reconstruct the pavement to study cold in-place recycling as an alternative option.

Test pits were excavated and samples were taken from each pavement layer separately to be tested. Results showed that existing pavement layers of 5 cm of asphalt wearing course, 10 cm of asphalt base course, 15 cm of road subbase and 50 cm of compacted subgrade soil. Testing was performed to determine the properties of each layer.

It was determined to mill 5 cm of existing wearing course, recycling of 10 cm of asphalt base course, 10 cm of existing road subbase, and a new overlay of 5 cm asphalt wearing course is to be constructed. Proportioning of mix design of recycled layer (stabilized road base course) is as follows:

- 96% of recycled material (asphalt + road sub-base)
- 1.5% of normal cement
- 2.5% of foamed bitumen (97.5% bitumen + 2.5% steam)

Material characterization of recycled mix was conducted utilizing Marshall Test in addition to Indirect Tensile Strength for dry and immersed samples for 24 hours. Testing indicated Marshall Stability of recycled material is almost same as the asphalt base course. Excellent strength and strength retention was noted after immersion of 24 hours in water of 25°C resulting in higher value of correlated layer structural coefficient (0.11/cm) leading to expected reduction in overall redesigned pavement thickness.

Execution was started by removal of existing wearing course of 5 cm, then recycling started by levels and slopes adjustment and specifying recycled thickness. During the recycling process additive (cement and foamed bitumen) percentages and recycling depths were continuously monitored. Samples of recycled material were taken from different locations for quality control and assurance. Once the recycling process was finished compactors were utilized to compact the recycled stabilized base course. After compaction, the road was opened to traffic by several days for curing to ensure full compaction and hardness of recycled layer. After a week from recycling is completed, the new asphalt wearing course of 5 cm was laid.

**Evaluation of Pilot Project Results**

Cold in-place recycling resulted in increasing rigidity of stabilized road base course that resulted in providing stronger support to asphalt wearing layer, leading to prevent structural rutting and fatigue cracking. In addition, the recycled stabilized layer reduces moisture susceptibility of ground water to asphalt. The layer coefficient of road base course was increased from 0.05/cm to 0.11/cm leading to more sustainable pavement design by decreasing the required thickness increasing pavement service life with the same layer thickness.

Comparison was made between conventional rehabilitation method, and the second option of cold in-place recycling. Comparison resulted in reduction of time and cost for recycling process than conventional rehabilitation by 75%, 30% and 40% respectively. This significant reduction in time, cost and energy consumption is referring to reduction of raw material production, transfer and construction for road base course material, raw materials for asphalt base course. In addition, construction time of recycling is greatly reduced by the construction technique itself, with rate of about 285 – 300 m2/hour.

Cold in-place recycling process resulted in several benefits for Abu Dhabi environment as follows:

- 100% of the existing road materials are re-utilized
- Reduction of the use of virgin materials of 80%
- Re-use of RAP binder, saving in energy for heating, transportation and construction of about 40%
- Reducing air and noise pollution
- Reduced traffic delay due to detours
- 83% reduction in carbon emissions

**Application of Pavement Recycling in Design of ADM Projects**

Cold in-place recycling was studied as a design option for the project ‘Pavement Rehabilitation of Road Network
at KHALIFA City (A), 2014 - Abu Dhabi'. Two design optioned were conducted considering conventional rehabilitation method by removal and reconstruction of the existing pavement, against application of cold in-place pavement recycling with foamed bitumen & cement. Several significant benefits were achieved.

Abu Dhabi Specification of Cold In-Place Asphalt Recycling
ADM team issued the first edition of ADM Specifications for Cold In-Place Recycling using foamed bitumen & normal cement at 2012, in order to start implementation for suitable projects. Specification included scope and references, component material requirements (aggregate, foamed bitumen binder, cement, and required quality of water), mix design requirements for recycled layer, and construction procedure and equipment. (11)

APPLICATION OF POLYMER MODIFIED BITUMEN AT ABU DHABI INTERSECTIONS
Several studies have revealed that properties of bitumen and bituminous mixes can be improved with addition of certain additives and the bitumen premixed with these additives is known as modified bitumen. Studies have shown that permanent deformation (rutting) within flexible pavement is usually confined to the top 100 to 150 mm of the pavement also known as surface course (9).

As traffic grows in Abu Dhabi asphalt rutting was observed at signalized intersections in Musaffah Industrial Area. As traffic congestion takes place on regular basis by heavy truck vehicles rutting is likely to be found.

ADM maintenance team proposed to study implementation of a different solution to reduce the high rate of maintaining asphalt pavement at intersection M7 at Musaffah Industrial Area, which more than 10 cm of asphalt rutting was observed. ADM technical team conducted a study in cooperation with maintenance team to use the SBS polymer modified bitumen in replacing the existing rutted asphalt to improve asphalt performance to resist rutting.

Study and Pilot Project Approach
As the SBS polymer is the most used elastomer and probably the most appropriate polymer for bitumen modification it was selected to be used as a polymer modifier for replaced asphalt base course and wearing course. The RWplast*M, is a granule composed of Plastomer and filler, which is designed to increase the resistance of base/binder course at high traffic zones. RWelast*E provides better resistance to permanent deformation, an increase in the road pavement lifespan and a reduction in maintenance operations of wearing course.

Implementation of Pilot Project
Pilot project was conducted in March 2015 to implement PMB at Intersection M7 in Mussafah Industrial area, Abu Dhabi as follows:

Evaluation of Existing Pavement Condition
Intersection M7 at Musaffah Industrial Area consists of one right turn lane, two through lanes and one shared lane for through and left turn, in addition to a shared lane of left and U-turn. Visual inspection showed medium to sever rutting at the left lane, ranging from 5 cm to 11 cm. and severe rutting at the mid three lanes 10-11 cm with medium rutting in the right turn lane.

Mix Design of Polymer Modified Asphalt Base Course and Wearing Course
Mix designs of asphalt base course and wearing course was conducted under the supervision of polymer supplier and ADM Material Quality Section, as per ADM standard specifications. The polymer RWplast*M was added with a percentage of 0.30% of the asphalt base course mix, and the RWelast*E was added with a percentage of 0.57% of the wearing course mix. Asphalt 60/70 was used for both asphalt mixes.

Laboratory Testing of Polymer Modified Asphalt Mixes Design
Mix design procedure for aggregates, bitumen and RWelast*E and RWplast*M granules for producing asphalts in the laboratory was conducted as per the ‘Protocol for making asphalts in the laboratory with RWelast*E solution’. Several parameters were considered as affecting rutting resistance in mix design; the first is binder content not to be high and grade not to be too soft, the second is the dosage of filler and sand not to be high, the third is the voids content to be in mid-range. Laboratory mix design was conducted as per European Standard (EN 12697-35), rutting test as per (EN 12697-22) and Asphalt Pavement Analyzer APA (AASHTO T 63) (16).

Execution of Pilot Project
The distorted area has milled to depth of 12cm, the wasted material has disposed properly away from the site, and surface was cleaned. Tack coat was applied and protected for 2hrs. Modifier product stored properly and transported to the asphalt plant as doses, the polymer was mixed with the aggregates before adding the bitumen under supervising of ADM Material Quality Section. The asphalt base course has transported to site, spread and compacted in a proper way. Wearing Course has spread as per ADM standard specification. Ceramic studs have been used as a road marking to finalize the surface and curb stone has repainted as finalize for the works of the asphalt.
**Evaluation of Pilot Project Results**

The use of PMB with asphalt mixes of asphalt base and wearing courses of Musaffah Industrial M7 intersection resulted in significant technical and financial benefits; better resistance to permanent deformation, an increase in the road pavement lifespan and reduction in maintenance operations. An Increase in asphalt layer cost of 13.9%/m² corresponding to extending in pavement service life from 8 months to 2.5 years was experienced.

**Abu Dhabi Specification of Rut Resistance Polymer Modified Asphalt Mixes**


**CONCLUSIONS**

- Achieving sustainable roads & infrastructures is one of ADM major objectives.
- Longer service life, less LCC, better serviceability, easier construction and maintenance, saving in raw materials, water and energy, less carbon emissions are basic considerations in pavement design for ADM projects.
- Application of geo-grid in mechanical stabilization and reinforcement of road pavement is considered as one of sustainable pavement design options, and resulted in significant technical, financial and environmental benefits.
- Pavement recycling approach is widely implemented over more than 30 years, as a major sustainable pavement rehabilitation approach and provided more durable road base course for rehabilitated pavement.
- Pavement recycling pilot project study and designed projects, resulted in reduction of cost, materials, energy and carbon emissions.
- Application of PMB asphalt mixes at heavy traffic intersections of Industrial city resulted in enhancement of rutting resistance and sustaining heavy traffic loading, and increased service life.
- Sustainable pavement design with geo-grid, pavement recycling and PMB asphalt mixes Approaches are complying with Abu Dhabi Government direction for implementation of sustainability principals in roads & infrastructure projects.

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INNOVATIVE APPROACH TO DEVELOP SMART PARKING SOLUTIONS ON PPP FORMAT

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ABSTRACT
Governments within the Middle Eastern region are looking for alternative approaches to meet the shortfall in infrastructure spending. Public Private Partnerships (PPP’s) have been implemented in the Middle East (ME) since the early nineties on an ad hoc basis, without the support of a PPP policy in place. The announcement of Dubai’s PPP Law No. 22 of 2015, an initiative aimed at developing infrastructure by fostering partnerships between government and private sector will help circumvent large initial capital investments and the project cost over a longer period of time. A consortium led by ITNL Infrastructure Developer LLC (IIDL), conceptualized the ‘Dubai Supreme Court Project’, a first of its kind PPP. The project aims to provide 200,000 ft^2 of leasable commercial and retail space and parking facility in excess of 1200 cars within a portion of the existing courts car park area which currently has 250 car parking spaces. This could be possible by implementing an innovative financing model and state of the art car parking technology.

PPP AS PREFERRED PROJECT DELIVERY APPROACH
United Arab Emirates
Over the past decade, despite the severe financial crisis, UAE in general and Dubai in specific has built a reputation of being one of the most stable & business friendly destinations in the Middle East. Keeping up with its image of providing the best of class services, Dubai has plans to deliver state of the art infrastructure across existing and new areas of development. However, in wake of the ongoing economic scenario, it seems to be a challenging task to meet its ambitious programme of investment. Considering this Dubai has started looking at various options and has expressed its interest in PPP mode of procurement. In order to improve private investments across infrastructure development, Dubai has recently enacted PPP law no.22 of 2015 aimed at achieving socioeconomic development in the Emirate. This move will help the government focus on the implementation of strategic projects in a more effective and efficient manner.

Parking Projects
Parking in Middle Eastern Cities
Development in the Middle East, particularly UAE, has boomed over the past few decades. This rapid growth and boom have led to a high movement of people, goods and services in the country. Owing to the growth in economy and population there has also been a surge in the density of vehicles. In most cities in the UAE, a typical urban setting is characterized by large, mixed-use city blocks or sectors. Most commercial and residential
areas do not have sufficient parking and the shortage of parking space in many areas in the UAE has led to serious concern among residents. In order to alleviate the existing parking problem and to accommodate future demands a number of parking demand studies have been undertaken which has indicated a huge supply-demand shortfall in the availability of parking spaces. Authorities in Dubai and Abu Dhabi have identified several areas lacking the required minimum parking spaces and those could be developed as multistoried parking projects.

Privately managed paid parking lots have mushroomed in many parts of cities in the ME Region. These parking lots cater the many demands of drivers who continuously scramble in search for parking lots. With such a huge shortfall, developing parking projects on private financing basis seems to be an emerging opportunity in the region with the government willing to leverage on exploiting land in order to create potential revenue streams (Dla Piper). With a new PPP law in place, the Private players in Dubai have expressed their interest in developing non-traditional sector projects such as ‘Parking’ on PPP basis.

Smart Parking Systems

Faced with increased environmental and economic pressure on city transportation, along with severe space constraints, cities all over the world are looking at new technologies and innovative approaches to develop parking to fulfil their current deficit and to meet the future demands. Smart parking can be considered as a label for technological innovations and efficient services monitoring and management of parking within an urban mobility strategy.

Smart parking systems has many definitions, however, the term used in this paper refers to Smart parking as an Automated Parking System (APS) designed to minimize the area required for parking cars. The automated parking system provides parking for cars on multiple levels stacked vertically to maximize the number of parking spaces while minimizing land usage. The APS generally utilizes a mechanical system to transport cars to and from parking spaces and avoid the time and effort taken by the driver to drive the car within the parking area in search of parking space. This resulted in elimination of the circulation space used in a traditional multi-level car parking area. APS is also generically known by a variety of other names, including automated car parking system, mechanical parking, and robotic parking.

Smart parking systems have an array of advantages. The most important advantage of smart parking systems is its implications on the environment. According to a study carried out in the United States in 2007 drivers in Los Angeles drove for more than 950,000 miles, emitted 730 metric tons of carbon dioxide and burned 470,000 gallons of fuel in search of parking.

Potential for Developing Smart Parking Projects Using PPP Approach

Parking provision is a commodity in the regional cities and for private parking areas; the pricing is based on demand supply gap. Considering increased land valuation due to the high density of development in the ME cities, government agencies are proactively seeking private investors to build public parking along with ancillary facilities on a commercial format. To make the projects viable, investors need to deploy technologies that are highly space efficient and has an ease to use for parking users. Automated robotic parking systems fit well in this market landscape.

Using this approach, government land currently being used for conventional parking areas that take roughly 30-35 m² per car space can be converted into Automated Robotic Parking Garages that can take approx. 12-15 m² of area per car. The space that is saved could be used for commercial exploitation purposes creating an additional revenue stream for the investor or providing more parking spaces thus substantially increasing the parking revenues. Dubai being the champion in adopting modern technologies took a lead in this area and approved a robotic parking project for an important public office building using PPP approach. This project is a pioneer in use of latest technology in car parking space and use of PPP framework in implementing urban projects, thereby bringing value to all the stakeholders.

DUBAI SUPREME COURT PROJECT

Background

Dubai courts is the seat of judiciary for the Emirate of Dubai and have other associated services where regular visitor inflow is a daily phenomenon. With a rapid pace of economic activities in Dubai over the last decade, the courts are getting busier and the existing court is facing serious constraints in the expansion of office area, improvement for public services and facilities. Dubai courts are facing extreme parking shortage through courts operating hours and were keen on exploring efficient parking solutions along with convenient facilities for court’s users and visitors.

In 2014, a consortium led by IL&FS Transportation Networks Limited, Dubai, presented a proposal to resolve parking problems by developing a robotic multilevel car parking facility in the existing court’s premises on a private finance initiative basis. Considering the project viability with no direct recourse to the government funding,
the project scope was evolved over intense consultative working sessions over the last one and a half year. Finally the project is conceptualized as the ‘Dubai Supreme Courts Project’ with an objective to convert a portion of the surface employee car park area of 250 car spaces, within the court premises, into a complete and integrated multi-use development of ~200,000 sqft to house the esteemed Supreme Court, its ancillary services and a state-of-the-art robotic car park with a capacity of more than 1200 spaces on the PPP framework. The project is a first of its kind conceptualized through a consultative discussion process with Dubai courts and various other Dubai government entities including Dubai Finance, Dubai Legal, Dubai Real Estate Authority and other relevant stakeholders. Finally, after enactment of Dubai PPP law in 2015, Dubai courts awarded the project in 2016 to the consortium on PPP basis for a concession period of 30 years.

**Project Structure**

In a PPP model, there is no ‘one size fits all’ concept owing to the flexibility of the type of arrangement that can be made between the private party and the public sector entity. ‘Generally, trust, openness and fairness are basic foundational underpinnings of successful PPPs’ (Jamali 2004). Based on this model the transaction structure was evolved with mutual consent with the government and the project is to be delivered through a Special Purpose Vehicle (SPV) formed by the Consortium members.

![Figure 1: Project Implementation Structure](image)

**Risk Sharing Mechanism**

Under the project implementation framework, the responsibilities for designing, building, financing, operating and maintaining are bundled together and transferred to the project SPV which have in turn transferred the risks to the equity partners. Due to the bundling of all sub component of a project into a single contract, the entire risks related to project delivery is passed on to the concessionaire (SPV) and in this project, these risks are assumed by the project sponsors which is different from a typical risk sharing model in any DBFOT contract. Following are the broad risks that are assumed by SPV in this project:

- Design
- Construction
- Programme
- Revenue
- Force Majeure
- Financing

As per the project structure, the project sponsors have committed to assume all the risks as listed above. The consortium members have taken full responsibility for delivery of the project within the cost and time defined in the concession agreement. The consortium members shall fund any cost overrun for reasons attributable to the consortium members with no liability on Dubai courts. Time overrun (for reasons attributable to the consortium members) shall invite levy of penalty by Dubai courts on the concessionaire.

The SPV shall enter into binding service level agreements with project sponsors specialised in their respective fields for ensuring the performance standards as defined in the Concession Agreement. The respective binding service level agreements would be executed with the respective project sponsors thus mitigating any time overrun, cost overrun and performance risks on part of the government.
Replication Potential
This Project being the first design, build, finance operate & transfer project in the area of smart parking solution to a public sector office has clearly got a replication potential across the region. Most of the government offices that cater to public services are facing parking problems. These offices are generally located within the heavily built up areas and has limited options to expand the public facilities. The parking requirements at these offices are much higher than the supply and further, the room for expansion is very limited due to space constraint. The solution to this problem is to use space efficient parking technologies. The proposed project includes the application of technology that uses 1/4th of the area of the conventional parking system. Thus resulting into providing of more than 1200 spaces where there are currently 250 spaces and also creating more than 200,000 sqft usable office space within the same plot.

KEY CHALLENGES IN THE TRANSACTION

Cooperation Between the Parties
A major challenge of PPP is cooperation between the public and private entity to achieve a common goal. It is a known fact that private agencies are profit oriented whereas public institutions often work to meet the basic necessities for the people. Engaging two parties with conflicting interests to put their ideas and resources together is difficult. However, with a strong agreement that binds two parties defining their roles and responsibilities and with proper legislation these challenges can be tackled proficiently. In the Dubai Courts Concession, both the parties in the initial stages realized the importance of cooperation and gradually during the process there was a synergy between the efforts of both parties and the project business case was reviewed in a transparent manner. Dubai courts being a profit share partner capped the cost with any over run to be funded by project sponsors off the balance sheet of project SPV.

Project Financing
For initial sets of PPP Project, it is expected that the government should provide some comfort to the project lenders, as they perceive a risk due to no track record of government in managing such projects. In the absence of any support from the government, lenders seek some extra comfort from the promoters and that results in the increased project cost or delayed project financing. In the Dubai Courts Project due to non-availability of any government backed security instrument, local lenders have seen this transaction as an unsecured project. Finally, the transaction was concluded with some experienced lenders on the basis of project recourse funding with guarantees given by the project promoters. From a risk perspective, the project is perceived as a real estate project rather than as an Infrastructure project. This led to lenders classifying such projects as high risk leading to higher financing costs. This could be mitigated if projects with the prime objective of resolving parking issues could be classified as infrastructure project with the requisite support from the government by way of providing some comfort to the lenders and allowing securitization of developed assets.

Understanding of PPP Amongst Various Stakeholders
Since the very beginning, governments across the GCC have funded large infrastructure projects from public sector budgetary allocation. Also, transferring the project rights to the concessionaire to develop and operate the project does not fit within the existing procurement and project approval rules. Dubai Supreme Courts Project being the pilot project has faced challenges and it has been a time-consuming process with various authorities’ approvals. However during the process these authorities have become familiar with the project structure and it is likely that for the other projects in pipeline, approval process would be seamless going forward. Developing a pilot project with a project champion is key to the success of implementing such projects.

Legal Framework
Although there are strong indications from governments in the region to enact a robust legal framework system to facilitate PPP Projects, the legislation development in most of these countries is still in its very nascent stages and it will take time for private investors to develop some level of confidence. Dubai has enacted the PPP Law, however in the absence of a central PPP unit it is very challenging to present a consolidate PPP pipeline to potential investors, and it is desirable to have a well thought-out framework for PPP to attract foreign investment. It is also expected that the legal framework should address the concerns regarding the SPV shareholding structure due to foreign ownership restrictions, foreign investment protection, dividend repatriation and mechanism of addressing termination events.

PPP Regulator
Under the newly enacted Dubai PPP Law, each government department can create their own PPP unit rather than a central PPP unit. This approach has both advantages and disadvantages. Due to the nature of PPP projects, which primarily involves long term association between a public and private entity, there needs to be an independent PPP regulator with a sound regulatory policy that ensures smooth and transparent implementation of PPP projects.
CONCLUSION

With oil prices showing no signs of recouping in the direction of previous highs and with the worldwide economic challenges, it would be wise to look at alternative methods of funding infrastructure projects in the ME Region and more and more government should look into developing projects on PPP basis. With the announcement of Dubai’s PPP law no.22 of 2015, Dubai has cleared its intention of developing a firm framework for execution of future projects on PPP basis. However, they need to work in setting up a detailed PPP framework and guidance material that potential investors and government departments can refer to while working on developing PPP projects. The Government of Dubai has taken a lead while approving the first project ‘Dubai Supreme Courts Project’ on a PPP basis. This may be used to develop similar projects across other departments in the UAE and wider regions and it will mark the beginning of a new era in developing infrastructure projects on Public Private Partnership basis.

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12. Organization and financing of public infrastructure projects- A path to economic growth and development


OPTIMIZATION OF THE DUBAI PUBLIC TRANSPORT SYSTEM

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OBJECTIVE

The main objective of this project is to analyze the traffic flow and congestion on Dubai roads at the various peak times and find ways to reduce this vehicular traffic by derailing the traffic towards the public transportation sector. The metro system was specifically analyzed; however, some modification was suggested for the other modes of public transportation. Most of the research done was based on weekday peak hour analysis.

METHODOLOGIES

Data Collected for Metro System on Weekdays

The Dubai metro runs 7 days a week with the average start time at 5:30 am and closing at 12pm every weekday. The frequency of the train arrival is heavily dependent on the time of day; however, on average there is a train every 5 minutes and at rush hour the time interval drops to 2 -3-minute intervals. Data was collected on multiple days of the week and the average for each day at each station were recorded and put in Tables 1 depending on what time the data was taken and which direction was being monitored.

DISCUSSION

As seen in the data collected in Table 1 and later plotted graph, the number of people who use the metro at both morning and evening peak hours varying per day and also in direction. The flow of people towards the Rashidiya direction on weekdays from 6-8am is less than that in the UAE Exchange direction likewise the flow of people towards the UAE Exchange direction on weekdays from 5-7pm is less than that in the Rashidiya direction. The reason for this may be because of accommodation pricing and location of the business district. The majority of workers work in the roaring Business Bay and Financial Centre areas, while living in the Southern Union and Burjuman area as a result of cheaper rent. So at the beginning of the day, the flow towards the business district is high which is noted in Figure 1 and the flow towards the Rashidiya district at the end of the day is high which is also noted in the figure. The flow of passengers in the counter-direction of the expected or estimated flow was also recorded and the massive decrease in numbers during both morning and evening rush hour was noticed.

IRF Examiner
### Table 1: Average Number of Tags at Select Station during Rush Hour

<table>
<thead>
<tr>
<th>Station</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6-8 am Weekdays towards Rashidiya</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Union</td>
<td>743</td>
<td>726</td>
<td>436</td>
<td>768</td>
<td>854</td>
</tr>
<tr>
<td>Burjuman</td>
<td>926</td>
<td>764</td>
<td>532</td>
<td>664</td>
<td>675</td>
</tr>
<tr>
<td><strong>5-7 pm Weekdays towards Rashidiya</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakheel</td>
<td>240</td>
<td>198</td>
<td>200</td>
<td>221</td>
<td>300</td>
</tr>
<tr>
<td>Internet City</td>
<td>167</td>
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<td>150</td>
<td>230</td>
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<tr>
<td>Business Bay</td>
<td>500</td>
<td>334</td>
<td>476</td>
<td>236</td>
<td>502</td>
</tr>
<tr>
<td>Dubai Mall</td>
<td>98</td>
<td>200</td>
<td>134</td>
<td>203</td>
<td>201</td>
</tr>
<tr>
<td>Financial Centre</td>
<td>105</td>
<td>189</td>
<td>300</td>
<td>302</td>
<td>376</td>
</tr>
<tr>
<td>World Trade Centre</td>
<td>336</td>
<td>403</td>
<td>410</td>
<td>320</td>
<td>423</td>
</tr>
<tr>
<td><strong>5-7 pm Weekdays towards UAE Exchange</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakheel</td>
<td>100</td>
<td>98</td>
<td>60</td>
<td>58</td>
<td>120</td>
</tr>
<tr>
<td>Internet City</td>
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<td>76</td>
<td>98</td>
<td>100</td>
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<tr>
<td>Dubai Mall</td>
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<td>130</td>
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<tr>
<td>Financial Centre</td>
<td>125</td>
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<td>101</td>
<td>106</td>
<td>113</td>
</tr>
<tr>
<td>World Trade Centre</td>
<td>103</td>
<td>89</td>
<td>68</td>
<td>98</td>
<td>107</td>
</tr>
</tbody>
</table>

### Figure 1: Average Tags at Select Stations at Peak Hour
SMART SOLUTIONS

Alternative 1

As mentioned in the discussion, the high congestion presently in metro stations in the business and tourist districts at peak hour is appallingly high and this reduces the service of the metro at that time frame. The metro stations are built in accordance with a permanent design, so reconstructing the station to increase the number of cabins would be uneconomical and insensible. To maximize the metro during rush hour, a different type of train should be used. Instead of the typical type with multiple seating, as seen in Figure 2, a light railway train with little to no seating should be used in order to fully maximize the carrying capacity of the metro during that time frame. If trains with such design are used only for peak hour transportation the number of people transported during that time frame will greatly increase all the while reducing congestion and increasing the carry capacity of the train per trip.

However, not all the seat will be removed as there will be special cases in which seating is prioritized; for example, pregnant women, disabled people and the elderly. So it is reasonable to leave a few seating positions for these groups of people. The newly designed cabins should have multiple railings in each cabin so as to prevent slippage when the train is in motion. This new design is similar to that of the aircraft-to-terminal shuttle, which is used to transport passengers from the aircraft to the terminal in cases where the aircraft lands far off from the airport terminal. In cases like this, the topmost priority is to carry the highest number of people at a time. An example is shown in Figure 3. These vessels are actually made to carry more people and luggage rather than built for comfort. If this is implemented in the Dubai metro specifically for peak hour conditions, there will be a huge improvement in the metro congestion.

Alternative 2

Another system that can be implemented is the Bus Rapid Transit (BRT). The BRT is an option that relies on the use of segregated lanes for buses to ensure faster and more efficient bus travel. This segregation ensures the public bus does not mix with the normal flow of traffic thus during peak hours this ensures that buses are not disrupted by the traffic congestion. The lanes are usually at the side of the road or in the center and they are constantly monitored to ensure normal vehicles don’t use these lanes. Implementing the BRT system in Dubai would greatly reduce the number of passenger vehicles on the major roads. The increase in service of the bus system will certainly lead to an increase in the flow of user to the public system. So, if people can use the bus and be ensured no delay whatsoever, there will be fewer passenger cars on the roads.

Figure 4 shows the possible outcome for the nearest future. A simple yet explicit cycle illustrating the domino effect the rise in population will have on the transportation sector. The BRT system will not only decongest the roads but will also have an environmentally friendly impact on the city. The lesser the cars are, the fresher the air is. The number of passengers that use the bus has significantly increased over the past three years however research shows that if the BRT is applied to Dubai roads there will be a much more tremendous increase. According to an evaluation of Bus Rapid Transit (BRT) in Dubai: “A proactive and attractive bus transport has the ability to reduce car population, decongest the city roads, reduce toxic emission, protect the urban environment and combat global warming. There is an imminent need to increase the attractiveness of bus transport by reducing the journey times in order to encourage a substantial shift from private cars. Public transport’s appeal hinges on its speed and regularity. There are research works to prove that public transport share is directly influenced by the ratio of public transport average speed to automobile average speed. The
most popular public transport networks are the ones that offer the best speed and regularity compared to the car. At present, bus journeys take twice as much time as cars to traverse similar trips” (5)

![Figure 4: Effect of an Increasing Population](image)

**Case Study: Lagos, Nigeria**

Lagos is located in the southwestern part of Nigeria, and it is known as the most populated city in Africa, it houses both the extremely poor and the overly rich. It is known to be the hub of Nigeria and therefore it is house to many people. The Bus Rapid Transit (BRT) was commissioned on March 17, 2008, by then governor, His Excellency Babatunde Raji Fashola. The lane ran for as long as 22 km spanning from downtown Ikorodu to Funsho Williams Avenue. A section of the BRT lane in Lagos can be seen in Figure 5. Maintaining the use of the lane was hectic as Nigeria is a country of great corruption and uncooperative citizens, but this was overcome by implementing soldiers at certain points to prevent normal passenger cars from using the designated lanes. Since it’s commencement the number of passengers increased to a roaring amount of 200,000 passengers daily and 4 million since it’s opening. Employment opportunities were made available and the traffic congestion reduced considerable (5). The Lagos BRT system caters to a city of over 21 million people and it does so effectively even though it is situated in a third world country that lacks most resources. The BRT had an impeccable impact on the congestion problem in Lagos so it can similarly relieve the congestion in Dubai.

![Figure 5: BRT Lane in Mile 12, Lagos, Nigeria](image)

**Alternative**

Dubai is considered an oasis in the desert for tourists and expat from all over. It strives on being a place of luxury and high expense and the people have high-end lifestyles. Knowing this, it is hard to assume or estimate that the high-class population would be willing to slum it in the typical concept of public transportation just to get home faster. Therefore, a different approach needs to be looked at all the while it being effective in reducing the congestion on Dubai major roads. The Personal Rapid Transit system (PRT), all be it expensive, would help a great deal in reducing the population of the middle class and upper-class drivers on the roads during the peak hours. The PRT can be situated in areas that are currently undergoing high urban sprawl which include the Dubai Silicon Oasis, the Dubai Sports city, the Dubai Motor city and any other areas. There has been a sharp increase in the number of housing being built over the past three years. A satellite image of these locations experiencing urban sprawl in Dubai between 2009- 2015 can be seen in Figure 6. According to expat arrivals, a great number of these housing facilities are only accessible by the middle and upper middle class in Dubai (7). This is the class the PRT should target, the working class that wishes to experience luxury all the while avoiding the traffic on their way to work.
The PRT system consists of small pods that are self-automated and run on special tracks that can span for kilometers. They can be bigger in size but in that case, that system would be called a Group Rapid Transit (GRT). These specialized taxis although expensive can do wonders in decongesting Dubai at peak times. If stations were implemented at urban areas and run through the traffic straight into the hub of business in Dubai like Business Bay, Media city, DIFC etc. The likelihood of the high-end class making use of it is high. The PRT is still in its beginning phases but it has been implemented in a hand full of places in the world (8).

**Case Study Heathrow Terminal 5, London, United Kingdom**

The PRT operating in the London Heathrow airport spans over 3.6km and consists of 18 driverless vehicles, which run on low energy. Ever since it opened consumers have complimented it for its easy accessibility, comfort, convenience, and safety. The pods do not waste too much time at stations and its speed, though slow allows the passengers to have a bump-free journey in good time. It is sustainable and it has helped reduce London’s carbon print. Similarly, the PRT in Masdar city, Abu Dhabi has shown tremendous result since opening in 2014, with 300 pods, 85 stations thus making on average 150,000 trips a day. Pods departing from the Heathrow terminal can be seen in Figure 7. The PRT system has some minor flaws in the sense that it is expensive to set up the tracks and buy the pod but in the long run, it is a huge bonus in reducing the traffic on Dubai roads coming from residential areas to the business districts.

Although the options explored seemed to tackle the issue of congestion in Dubai, other factors seem to have been overlooked such as the change in climate condition in Dubai. One of the methods used to make the public transport sector appealing to all classes was to make it convenient. Dubai is prone to heat and humidity in the summer months. During this time frame, people are less likely to use public transport as it would be strenuous and tiring. At this point in time, access to any mode of public transportation should be made easy and promotions should be implemented to cajole the users to engage in the use of public transport even when under such excruciating conditions.

The drainage system in Dubai should be considered. Dubai does not have a good drainage system, so when unexpected rain falls the service of the roads gets worst thus affecting all modes of transportation. New innovative bus to boat vehicles can be added to the public sector to compensate in situations like this. An example of such can be seen in Figure 8. Other options, could involve changing a few transport policies such as the time heavy duty vehicles can be on certain roads, also more fees and rules could be enforced on passenger car holders to pressure them into using the public system sector thus gradually reducing the traffic congestion.
The world is fast evolving and for societies to keep up with the dynamic changes going on new innovations must be applied. Smart transport solutions deal with the utilization of innovation to improve vehicular availability/accessibility and the transportation sector for convenient movement in the general public all the while conforming to modern approaches. The solutions given below are additional plausible solutions for the congestion on Dubai streets.

- Electronic payment option should be implemented in the RTA taxis. RTA needs to adopt a more advance payment strategy. Users should be given the option of paying using an online virtual Identity, which entails all their financial details. UBER is growing constantly in the UAE demographic and this growth is poaching consumers from the RTA public transport. An update from the archaic and normal means of taxi transportation would both increase revenue and reduce private vehicles on the road and this will create an uphill effect of reduced carbon emission.

- Bus routes should be recalibrated and reconstructed to mitigate harmful and wasteful emission.

- Implementing seaplane service would be able to maximize all routes of public transport. Dubai has various areas with access to a body of water and applying this new and innovative form of transportation increases Dubai’s level of advancement to remarkable heights. This transport mode was used in the past to move between the Emirates, so routes can be easily calibrated.

These solutions will reduce the number of personal cars all the while increasing the efficiency of modes of public transport in the Emirate.

CONCLUSION

The purpose of this project was to evaluate the congestion of traffic in Dubai during rush hour and find solutions using the public transportation sector to reduce the congestion. The solutions suggested were environmentally friendly and economically plausible, meaning it would yield profit in due time after implementation. The first alternative of different trains being used during rush hour may pose a great adjustment problem because it would take a while for the consumers to get used to such change. Economically this would profit the government because more people get to use the metro at peak times thus increasing the profit margin for the metro; however, the revenue on vehicles and vehicle-related expenses would drop a get deal and this would also affect the economic aspect of things. These factors are applicable for all alternatives suggested. They all help the environment because less congestion means less emission; they all benefit the societal aspects of things by increasing the tourist flow to Dubai and they all benefit the economic aspects of things for the public transport sector all the while reducing the revenue gotten from private car owners. The main obligation for any of the designs is to the public. The consumers’ needs should be the topmost priority and until most of their needs are met different suggestions must be made.

REFERENCES


THE APPLICATION OF INNOVATIVE GEOMETRIC DESIGNS TO ADDRESS PLANNING, FUNDING AND LAND USE CHALLENGES

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ABSTRACT
This paper presents a case in the city of Riyadh where there is an increased recognition of the urban land use planning and the importance of travel demand models. This paper focuses on a corridor that was selected to be upgraded to a principal arterial in the city to improve the connectivity and roadway network hierarchy in the city. A certain section of the corridor upgrade faced challenges related to funding and land use accessibility needs that limited the possibility of applying grade separation of the intersection on that corridor section. To solve that issue an unconventional geometric design solution called ‘Synchronized Split Phase Intersections’ was applied. The results of the before and after study are presented in this paper along with the major issues encountered. The results showed improvements in the level of service and reduced delays despite the increased demand on the corridor after the upgrade.

INTRODUCTION
The need to control and direct the urban growth in Riyadh City lead to the formulation of the first Master Plan for Riyadh in the early 1970’s (Al-Hathloul, S. 2017), this plan aimed to provide guidance for the growth of the city up to the year 2000. The drastic changes to the economic and social aspects of the urban development in Riyadh following the oil boom in the mid 1970’s emphasized the need to have a well-structured urban growth planning process that corresponds to the city’s rapid growth. This materialized into several contracts between the Saudi Government and the different consultants to update and develop the Master Plan for Riyadh City until the Arriyadh Development Authority (ADA) was established and took several strategic initiatives to help guide the city’s rapid urban growth and maintain the livelihood of the city (Al-Hathloul, S. 2017).

The unconventional urban growth rate in Riyadh resulted in some gaps between land use planning and the needed transportation infrastructure to support that growth. To
help better estimate the impacts of changes in the land use and transportation infrastructure on the demand for travel in the city, the Municipality of Riyadh (Amana) developed and updated the travel demand model for Riyadh. This model is being used to evaluate the different future alternatives related to land use and transportation infrastructure in the city. In the following sections, this paper provides a detailed description of the metropolitan travel demand model for the city of Riyadh and its use.

Also, this paper presents a case study of a corridor that was selected to be upgraded to a principal arterial in the city in order to improve the connectivity and roadway network hierarchy in the city. A certain section of the corridor upgrade faced challenges related to funding and land use accessibility needs that limited the possibility of applying grade separation of the intersection on that corridor section. To solve that issue an unconventional geometric design solution called 'Synchronized Split Phase Intersections' was applied at the site with great success. The results of the before and after study are presented in this paper along with the major issues that were encountered during the development of the design and performance analysis. The results showed improvements in the level of service for the intersections and reduced delays despite the increased demand on the corridor after the upgrade of the corridor.

CASE STUDY

The Municipality of Riyadh developed and updated a travel demand model for the city to be used for the analysis of different future development scenarios in the city. The following is a description of the travel demand model and the case study used.

Riyadh Travel Demand Model

The City of Riyadh has an estimated 7.4 million daily trips on its roadway network travelling a total distance of 102 million kilometers, and almost 77% of those trips are made by personal vehicles as shown in Table 1, which reflects the official numbers provided by the Municipality of Riyadh. Like many of the other major cities in the world, the city of Riyadh is suffering from a deteriorating level of service (LOS) and increasing travel delays affecting the mobility needs of the roadway system users. A major cause of this is the gap between urban growth and land use planning which is creating mobility challenges due to the difficulties in coordinating transportation infrastructure needs and land use. Many of those challenges could be alleviated by improved connection and balancing between mobility needs and land use to create livable communities. In the city of Riyadh there is an increased recognition of the urban land use planning and the importance of travel demand models to provide better analysis and utilize the available resources to the best possible extent.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jurisdictional area (km)</td>
<td>4,614</td>
</tr>
<tr>
<td>Developed area (km)</td>
<td>1,913</td>
</tr>
<tr>
<td>Population</td>
<td>6,506,700</td>
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<tr>
<td>Auto ownership (veh/HH)</td>
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</tr>
<tr>
<td>Number of workers</td>
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<td>Number of daily trips</td>
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<tr>
<td>Daily VKT (km)</td>
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<td>Daily VHT (hours)</td>
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<tr>
<td>% of private vehicles trips</td>
<td>77</td>
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<tr>
<td>% of public transit trips</td>
<td>3</td>
</tr>
<tr>
<td>% of heavy vehicles trips</td>
<td>20</td>
</tr>
</tbody>
</table>

The city of Riyadh has 15 sub municipalities, which include approximately 170 neighborhoods, and all of them are under the jurisdiction of the Municipality of Riyadh (Amana). The Amana developed and updated the Riyadh Travel Demand Model (RTM) to better estimate the impact of the socioeconomic and infrastructure changes to the users of the transportation system. The current RTM has more than 2450 traffic analysis zones (TAZ) with the different land uses and socioeconomic properties updated and coded. The RTM update included adding 1780 km of new roads and updating the characteristics of 940 km of the modeled roads from the previous model. The updated RTM also included updating the land use data for 400 TAZ’s and 18 super zones as shown in Figure. It represents a significant effort by the Amana to have a reliable well structured approach to evaluate the effects of the different changes on the land use and infrastructure in the city.

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Table 2: Exiting and Future Roadway Lengths by Functional Class in the City of Riyadh

<table>
<thead>
<tr>
<th>Roadway functional class</th>
<th>2016 (existing) roadway length (km)</th>
<th>2025 (planned projects) roadway length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressway</td>
<td>470</td>
<td>820</td>
</tr>
<tr>
<td>Principal Arterial</td>
<td>480</td>
<td>810</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>340</td>
<td>460</td>
</tr>
<tr>
<td>Collector</td>
<td>1,930</td>
<td>2,130</td>
</tr>
</tbody>
</table>

The case study presented in this paper is the ‘Prince Turki Bin Abdel Aziz Al Awwal’ corridor which was selected to be upgraded into and express way to ease the North-South movement of the vehicles in the northwestern part of the city as shown in Figure 2.

Figure 2: Prince Turki Bin Abdul Aziz Al Awwal Corridor

This corridor was selected to be upgraded to relieve some of the traffic congestion on the parallel Takhassosi Rd. and King Fahad Rd. The upgrade included introducing grade separated intersection by providing tunnels for the through traffic movement on Prince Turki Rd. on its intersections as shown in Figure 3. The construction has already finished on some of the intersections and will finish very soon on the remaining intersections except for the intersection of Prince Turki and Mecca roads. This particular intersection faced many challenges that affected the planned upgrade to grade separated intersection and had to be treated in different way than the other intersections on the corridor.

The Intersection of Prince Turki Bin Abdul Aziz Al Awwal and Mecca Roads

The upgrade of the intersection between Prince Turki and Mecca roads faced many challenges related to funding, adjacent land use and accessibility needs. The intersection and surrounding land use is shown in Figure 4. As can be seen from the figure, there is an underpass on Mecca Rd. and there was a plan to have another overpass on Prince Turki Rd. to improve the North-South traffic movement on the corridor. The surrounding land use included schools, residential buildings, embassy and several highly active commercial complexes. The addition of the overpass would have a severe impact on the accessibility to the surrounding land uses, which already exist. Also, with the planned opening date for three of the grade separated intersections to the north of this location there were many fears that this intersection would have increased traffic volumes and severe delays due to the existing conditions at the site which will affect the success of the corridor upgrade and the resources that were invested in it.

Figure 4: Land Use Surrounding the Intersection
Based on the previous discussion, efforts were made investigating other alternatives for the intersection configuration that could provide the needed levels of accessibility to the surrounding areas. Also, the suggested alternative shouldn't involve major construction efforts to have it ready by the planned opening date of the other upgraded intersections to the north of the location. The RTM was used to estimate the future volumes on the corridor after the planned changes to the roadway network and those volumes were also used in the traffic analysis for the different alternatives using PTV Vissim software. The results of the analysis concluded that the best alternative to be applied at the location given the local conditions was a modified synchronized split phase intersection. The description of the design and the analysis are provided in the following sections.

MODIFIED SYNCHRONIZED SPLIT PHASE INTERSECTIONS

The synchronized split phase intersection is an unconventional geometric design that is used for surface intersections and could be applied under certain conditions with relative success when compared to the conventional geometric designs under the same conditions (FHWA 2010). This type of design is also known in some parts of the world as the double crossover intersection. The main concept from the design is to allow the through and left-turn movements on the mainline to cross over before the main intersection. For the main intersection traffic, the through and the opposing lefts can move concurrently during the same signal phase. This intersection can then operate with two phases. Figure 5 illustrates the main movements on synchronized split phase intersection.

![Figure 5: Typical Double Cross Over Intersections Layout (Source FHWA 2010)](image)

This unconventional design is perceived to be most beneficial in improving the LOS in locations where high left turn and through volumes lead to high delays. The design enables the signal phases to be reduced by allowing movements from the ramps to proceed concurrently with the through movements on the crossroad. The result of this will be that signalized crossovers operate with two phase signal control. Another main advantage to this type of design is that it improves the traffic safety at the locations because it has fewer conflict points compared to a conventional design and this should reduce the number of crashes at the site.

However, one of the major issues, which the designer should make every effort to address, is the driver confusion that may result from the reversed direction of travel for drivers between the two edge intersections. This could be reduced by introducing proper curve designs to channelize the traffic, proper traffic signage and lane marking. Also, new innovations in intelligent transportation systems (ITS) could help guide drivers throughout the intersections area.

Access Management Considerations

Due to the special nature of the traffic movement on this type of design there should be special consideration to the effects of applying this design on the adjacent land uses on case by case basis. This type of design is usually applied within urban areas and because of the special nature of the design there is a need for the inclusion of frontage roads to provide the needed accessibility for the adjacent lands. This will create a need to include additional phasing into the signalized intersections in the design, which will impact its efficiency. Another accessibility issue is the restrictions on the U-turn movements mainly due to the crossover of traffic movements within the design. If the road width is acceptable, signalized protected U-turn movements could be incorporated within the wide medians upstream and downstream from the main intersection. However, their signal phasing must be synchronized with the signal phasing of the other intersections to make sure there is no conflict between the different traffic movements on the intersections and there is a smooth flow of traffic through the intersections.

TRAFFIC ANALYSIS

The traffic analysis process included performing traffic counts and roadway inventory on the intersection to estimate the existing traffic operating conditions. That was followed by using the RTM to estimate the short term future traffic volumes that will be using the intersection area after the upgrade of the ‘Prince Turki’ corridor.

Microsimulation was used to analyze the performance of the intersection area for the different scenarios using PTV Vissim Software. The results of the analysis showed that the synchronized split phase intersection design provided the required levels of operational performance and accessibility at the intersection site. The analysis showed that the application of this design will help reduce the congestion at the site by operating the intersection as a two-phase signal instead of the existing four-phase signal. The synchronized split phase intersection design also provided the needed levels of accessibility to the different land
uses surrounding the intersection through the provision of adequate U-turn movements and service roads. The results of the delay and traffic volume comparisons between the existing condition and the suggested design from the RTM and Vissim are provided in Figure 6 and Figure 7 respectively. As for the maximum queue length comparison, it is provided in Figure 8.

As can be seen from the previous figures, the RTM showed there will be an increase in the volume of vehicles attracted to the intersection by 20% due to the upgrades planned for the Prince Turki corridor. However, due to the design features of the synchronized split phase intersection and the traffic volume of the different movements at the intersection the micro-simulation showed that there will be a reduction of the average vehicle delay by 130 seconds. This indicated that the LOS will change at the intersection from LOS ‘F’ to LOS ‘B’ without the need to go for grade separation at that location. The design proved to be the best solution at the site due to the heavy left turn traffic movements, and it was operated as a two phase signal with minimal vehicle queues.

The design was constructed at the site at the end of the year 2016 and it has been operating with a great success. The city officials are monitoring it continuously and efforts are being made to adapt it to other locations in the city of Riyadh. The final layout of the intersection is shown in Figure 9, and a photo of the intersection after it was constructed is shown in Figure 10.
CONCLUSIONS

Due to the gap between urban land use planning and infrastructure needs planning there are many challenges facing effective transportation network upgrades. This paper presented a case in the city of Riyadh, KSA where a corridor upgrade was faced by financing, time and surrounding land-use issues that limited the application of traditional geometric solutions to traffic problems on the corridor. An unconventional geometric design solution called ‘Synchronized Split Phase Intersections’ was applied at the site with great success, and the design proved to be the best solution at the site due to the heavy left turn traffic movements, and it was operated as a two-phase signal with minimal vehicle queues. This paper concluded that unconventional geometric solutions can be utilized effectively to balance between mobility and accessibility levels at certain sites to deal with untraditional conditions that may exist as a result of the backlog in urban planning and exiting transportation infrastructure.

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GEOGRID IN PAVEMENT STRUCTURES

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ABSTRACT
The United Arab Emirates (UAE) federal government requests that sustainable solutions be explored in the design stage. One option is to use a geogrid in the pavement structure by placing it in the asphalt layer to control reflective cracking. Placing a geogrid in the aggregate layer reduces the pavement structure’s total thickness; it also increases pavement life and reduces cost, material use and carbon emissions. Geogrids have been used in several roads in Abu Dhabi (Abu Dhabi Municipality), as well as in other Gulf Cooperation Council (GCC) countries (Kuwait, Qatar, and Oman), mainly for roads built on weak soil such as Sabkha.

The use of geogrids in pavement layers is governed by two criteria: specifications and this acceptance guideline. This paper discusses the specifications and criteria required for the use of geogrids in pavement structure.

GEOGRIDS MATERIAL AND USE
Geogrids, are synthetic fabric materials that is used in pavements for separation, reinforcement, filtration, or drainage. They can also be combined with asphalt binders to form a waterproofing membrane. Geogrids use different synthetics and different products providing various properties and characteristics. Modern pavement designers have limited fundamental modeling of how the inclusion of geogrids impacts pavement design. Some agencies recommend avoiding the inclusion of geogrids as structural elements in pavement designs until the industry better understands their fundamental properties and developed proven standards for their inclusion.

Some designers use geogrids on a small scale and monitor the pavement performance over time to better understand their impact on pavement designs. Per AASHTO’s Recommended Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures (AASHTO R 50-09), designers should conduct field tests by including geogrids to reinforce sections of aggregate base layers in pavement structures. Suppliers of geogrids should follow this process to provide sufficient evidence of such materials’ potential adequacy in pavement structures.

Geogrids are used to reinforce asphalt to control reflection cracking as described in Austroads, (2008). The action of geogrid reinforcement in controlling reflection cracking is different to that of a strain alleviating membrane interlayer (SAMI). SAMI treatments, including geogrid reinforced seals, use bitumen as a waterproofing and strain alleviating membrane layer. Geogrids control strain in the asphalt through the tensile strength of the reinforcing grid.

Some research suggests that geogrids may also be used to reduce rutting in asphalt layers or to improve structural performance to allow a reduced thickness of asphalt. Design criteria for such applications are not well defined and selection is largely based on reports of observed performance provide by suppliers.

To avoid void spaces between the geogrid and underlying surface, the geogrid is generally placed on an asphalt corrective layer or held in place with a sprayed seal. Some fiberglass geogrids are supplied with an adhesive backing to hold them in place while placing asphalt. Sliding and buckling of polyester and polypropylene geogrids during the placing of asphalt can be difficult to control unless the geogrid is held in place by a sprayed seal. Geogrids are normally placed directly under the wearing course. Generally, a minimum covering thickness of 50 to 70 mm is recommended to ensure that the geogrid is firmly held within the asphalt structure.

The benefit of using geogrids in pavement structure is high. Geogrids are considered a sustainable design as it will lead to reduction in materials. However, the concern is how to specify the geogrid for a certain project and how to obtain the design. Different suppliers will provide different geogrids that vary in properties and most importantly
performance. The following sections will discuss geogrids specification and design, then it will be concluded with guideline requirements to enhance the use and acceptance procedure of geogrids in pavement construction.

**GEOGRIDS SPECIFICATIONS**

Most of the geogrid specification focus on material physical properties and strength, such as in Australia (Austroads, 2008), which compared different classes based on elongation and a set of strength tests such as Grab, tear and puncture strength. The target values set for these tests were obtained from AASHTO Standard Specification M288-06 (AASHTO 2006) as shown in Table 1.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
</tr>
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<tbody>
<tr>
<td>Grab strength (N)</td>
<td>AS 2001.2.3.2</td>
<td>&gt; 50%</td>
<td>&gt; 50%</td>
<td>&gt; 50%</td>
</tr>
<tr>
<td>Tear strength (N)</td>
<td>AS 3706.3</td>
<td>450</td>
<td>350</td>
<td>250</td>
</tr>
<tr>
<td>Puncture strength (N)</td>
<td>AS 3706.4</td>
<td>2,750</td>
<td>1,825</td>
<td>1,230</td>
</tr>
</tbody>
</table>


In addition to the strength requirements other department such as Texas Department of Transportation (TXDOT, 2009) also specified shape thickness and Ultraviolet, as shown in Table 2.

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture shape</td>
<td>ID Caliper</td>
<td>Triangular</td>
<td>Triangular</td>
</tr>
<tr>
<td>Aperture size (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rib thickness (mm)</td>
<td>ASTM D1788</td>
<td>50 typical</td>
<td>60 typical</td>
</tr>
<tr>
<td>Rib Shape</td>
<td>Observation</td>
<td>Rectangular</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Flexural Rigidity (mpa)</td>
<td>ASTM D6637</td>
<td>250,000</td>
<td>750,000</td>
</tr>
<tr>
<td>Min Radial Stiffness @ 0.5% strain (lb/ft²)</td>
<td>ASTM D6637</td>
<td>15.430°</td>
<td>20.580°</td>
</tr>
<tr>
<td>Junction Strength (Efficiency) (%)</td>
<td>GRF-062-87</td>
<td>93 min.</td>
<td>93 min.</td>
</tr>
<tr>
<td>Ultraviolet Stability (%)</td>
<td>ASTM D4555</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>


PAVEMENT DESIGN USING GEOGRIDS

Conventional pavement designs are carried out as per 1993 AASHTO pavement design guidelines or any other pavement design procedures. Then this conventional design is given to the geogrid suppliers who will analyse the pavement design and provide alternative design using geogrids. The geogrid suppliers provide data sheets as per AASTHO R50-09 requirements and carry their own pavement design tool to obtain the alternative design.

As an example, the following pavement section (Figure 1) was designed for a project in the UAE. The main section of the road is located on regular existing soil but the client would like to explore the use of geogrid as a sustainable alternative.

Two different geogrid suppliers were approached for this project. Each supplier provided different alternative design to the original pavement section shown in Figure 2 and Figure 3. The difference in pavement section comes from the difference in the geogrid type for each supplier.

However, the most important property that will impact the design is the mechanical property that influences performance of the geogrid in the pavement structure. The mechanical properties are addressed in AASHTO R50-09. AASHTO R50-09 required performance testing conducted for each type of geogrid proposed including woven, welded, extruded, punched and drawn biaxial geogrids, and punched and drawn triaxial geogrids. Different performance tests need to be carried for different subgrade conditions within different soil types. Reinforced sections must be compared to corresponding control sections for each subgrade condition. This testing must be carried at the site by the contractor or provided by geogrid manufacturer.
As can be seen from the previous figures, that both pavement designs provided a reduction in materials, which leads to reduction in virgin material, carbon emission and cost. The use of geogrid in pavement structure is a sustainable solution to reduce the pavement thickness. However, the design of the reduced section relies on the type, strength, and shape of the geogrid, which differ from one supplier to the other. Suppliers provide the alternative design based on their recommended geogrid type according to their own production properties. This is a major concern especially, if there are several suppliers from different countries where the quality control is not monitored. Guidelines need to be placed in the project specifications for selection and acceptance of geogrids to reduce pavement structure layers.

GUIDELINES FOR USE OF GEOGRIDS IN PAVEMENT STRUCTURE

Having several geogrid suppliers is good practice. Data from the supplier and the performance of the geogrid need to be verified and confirmed to avoid major road failure. Based on the above discussion and to use geogrid in the pavement structure, the following guidelines need to be followed to control the used and design of geogrids.

These guidelines are based on Abu Dhabi Municipality (ADM 2014) procedures that were developed for Emirates of Abu Dhabi. The guideline cover the acceptance of the geogrid supplier, the geogrid testing, pavement design procedure, construction requirements and quality control / performance testing after construction.

The following are each guideline in more details.

Geogrid Supplier
- Geogrid supplier must be approved by the agency as an acceptable geogrid supplier.
- Supplier should provide previous experience in the Middle East (preferably UAE).
- Supplier will support the contractor during construction to confirm method of placing and fixing the geogrid in the pavement layer.
- The contractor will give a warranty on the pavement for any defects that might be caused by the geogrid.

Geogrid Testing
- Geogrid Material properties need to be verified by an independent laboratory. The contractor shall provide a certificate demonstrating compliance with the specification to the engineer for each pavement geogrid material used, and proposed to be used in the contract.
- All test results on which the certificates are based shall not be more than one year old, measured from the date of supply to the site.
- Results of full scale accelerated testing should be provided. This test should have been carried out in an internationally recognized laboratory to assess the general performance of the geo-girds.
- Additional trial section - full scale accelerated testing is required as described in AASHTO R50 -09. This trial test will be carried at the commencement of the project by the contractor using the proposed geogrid to evaluate the performance of this type of geogrid and its suitableness to the project condition. Location and length of the test section will be agreed upon with the Ministry and the engineer.
- The trial section will be built using the alternative pavement option recommended. The performance of this section should be monitored for short period of time to verify its adequacy.
- Based on this trial section the final recommendation to use or not to use the geogrid will be made.

Pavement Design
- Detailed pavement design calculations and report should be submitted for including geogrid within the pavement structure.
- The design will be based on the conventional design (without geogrid).
- Provide design should respect the layers used in the conventional design. The alternative pavement design should not eliminate a complete layer from the conventional pavement structure. It should only result in reducing the thickness of the layers as practical.
• Geogrid use should be limited to aggregate layers only, not in the asphalt layer.
• Several design options should be explored to obtain the most sustainable cost effective design option.
• The pavement design should be based specifically for the proposed geogrid not for “Equal Geogrids”.
• Design steps from agency design manual and acceptance criteria should be followed.
• Detailed bill of quantities and cost estimate will be provided for each option.
• Pavement design will be carried and provided by the supplier / manufacturer. Then the engineer will review it.
• Pavement design should be based on 1993 AASHTO pavement design guidelines.
• Pavement design software can be used after approval from the Ministry and engineer.
• Life cycle cost analysis will be carried and included in the pavement design report to compare between different proposed options.

Field Construction
• All acceptance tests and specification for pavement layers should be satisfied and met with or without geogrid.
• A construction procedure detailing all work shall be prepared.
• The proposed construction procedure shall be submitted to the engineer at least 14 days prior to the commencement of any works related to the placement of the pavement geogrid material.
• No works related to the placement of pavement geogrid material shall commence until the engineer has approved the construction procedures and the engineer has given the contractor permission to proceed.
• The placement and compaction of the aggregate layer on top of a pavement geogrids in the field can result in installation damage to the geogrid materials. This is typically reflected by a reduction of the tensile strength properties of the geogrids. The amount of installation damage is determined by subjecting the geogrids to a backfill and compaction cycle, exhuming the material, and determining the tensile strength retained within the geogrids. The ultimate tensile strength of the uninstalled product is compared to the ultimate tensile strength of the installed product to derive at the installation damage reduction factor.
• Supplying of geogrid rolls with each roll having adhesive tape fixing bands or printing directly on the material identifying the product name, and its manufacturing style code. The labelling/printing is preferably at 5 m spacing along the length of the roll of pavement geogrid material. If the pavement geogrid product proposed has difficulties with labelling/printing, the supplier is to propose a method of identification to be considered by the Engineer.
• Deliver geogrid reinforcement to the site at least 14 days prior to commencement of installation.
• Store geogrid reinforcement to avoid any damage prior to installation. Do not store the reinforcement directly on the ground or in any manner in which it may be affected by heat. The method of storage must be in accordance with any other recommendations set by the manufacturer.
• Layer under the geogrid shall be prepared prior to placement, providing a level and uniform ground surface, with appropriate clearing and grubbing performed to accomplish this.
• The pavement geogrid shall be installed in accordance with the lines and grades shown on the plans and specifications. The geogrid shall be oriented such that the roll length runs parallel to the road direction. Geogrid shall be laid flat and smooth directly on the prepared surface. All wrinkles and folds shall be removed.
• The geogrid shall be overlapped a minimum of 300 mm in longitudinal directions, or joined as specified in the project plans or as directed by the engineer. Soft subgrade installations may require a greater overlap and in some cases, geogrids may be joined using cable ties or other suitable methods to maintain the geogrids location and orientation during fill placement.
• Prior to placement of the aggregate material, the engineer, to make sure it is placed in the proper location, and has not been damaged during delivery and placement, shall inspect the geogrid. Damaged geogrid shall be replaced immediately.
• Care shall be taken to ensure that geogrid sections do not separate at the overlaps during construction. Road base material shall be placed in lift thickness as shown on the plans. Tracked construction equipment shall not operate directly upon the geogrid. A minimum compacted fill thickness of 200 mm is required prior to operation of tracked vehicles over the geogrid. Any ruts occurring during fill placement shall be immediately filled in with a suitable capping material.
• A representative sample shall be taken from the roll(s) to be tested in accordance with ASTM D4354. The representative sample shall be no less than four linear meters along the roll for the full production width but not within two meters of the start or end of the roll. The sample will be taken for every 15,000 m2.
CONCLUSIONS

There are several benefits for using geogrid in the pavement structure. All of these benefits are sustainable benefits that will reduce raw material usage and reduce the carbon footprint, which is an environmental advantage. In addition, there will be cost saving in using an alternative smaller pavement section. However, the problem faced is that geogrids differ by different suppliers due to material type and even within same supplier due to shape and strength.

Accordingly, there is a need to provide guidelines that will control and regulate the use of geogrids in pavement structures and will ensure that performance of the pavement section.

Abu Dhabi Municipality (ADM 2014) provided guidelines that were proven to be good procedure to follow to ensure the geogrid use. These guidelines covered the selection of the geogrid supplier, the properties of the geogrid, the pavement design method using geogrids, the construction procedures for the geogrids and performance of geogrids in a pavement structure.

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PERFORMANCE BASED MAINTENANCE CONTRACTS FOR THE FEDERAL ROAD NETWORK IN THE UNITED ARAB EMIRATES

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ABSTRACT
As part of the improvements performed by the United Arab Emirates (UAE) Government in the infrastructure services, the Ministry of Infrastructure Development (MoID) decided to implement a Performance Based contract for the roads daily maintenance within the federal roads network.

The format of the contract was decided after a deep internal study and analysis within the Roads Department, which helped to create the best contract format for the MoID needs.

One main aspects to be evaluated was which items should be included within the performance criteria and the definition of their time response and level of service of each one of them as well as the works in which maintenance consist in.

The main goal of the project is to improve the roads maintenance quality and reduce the time response to attend those tasks. Some other services provided will help to reach this objective.

INTRODUCTION
The Roads Department in the Ministry of Infrastructure Development is responsible for the maintenance and conservation of the federal roads network. The main objective of the department is to keep a good level in the roads maintenance since safety and operational conditions of the network depend on them and those are considered the main indicators for the Department to satisfy the citizens demand.

As part of the federal policies to increase quality and safety UAE government the national agenda 2021 was launched. This agenda includes a set of national indicators in different sectors as education, healthcare, economy, police and security, housing, infrastructure and government services. All of them are long-term, measuring performance outcomes according to each one of the national priorities comparing UAE with global benchmarks. The performance of these KPI values will be established by periodically monitoring.

In order to reach the goals contained in that national agenda, UAE government needs to improve procedures and methods. One of these important changes came with the new format for the roads maintenance contract, evolving from the typical work orders to a first stage in a performance based contract. These types of contracts are typically awarded for a minimum of five years.

The contract started on March 2017, but to match the most common assignation criteria, the first stage will be implemented in a frame of time of two years and inside the terms of reference, it is considered the possibility to extend two more years and renew an extra one (depending on the contractor general performance during the contract).

Works are divided in two main types: Performance or Routine Maintenance (RM) and Work Orders (WO).
ROADS MAINTENANCE DESCRIPTION

Traditionally the roads maintenance in the Federal Roads has been performed by work orders, meaning that anytime something was needed it was requested to be fixed by the contractor.

These work procedures were improved by introducing concepts as compulsory programming and delay penalties, but in any case, the procedure still in the pure corrective maintenance side.

The traffic growth factors within the network indicating the users’ demand in the roads is large, and all factors are indicating that this tendency will remain as it is now at least for the coming three years.

Through the counting stations located in the roads network, some of those high growth factors detected, as an example were: 10% in road E-611 (Emirates road), or 8.5% in road E-88 (Sharjah – Dhaid – Masafi) from 2015 to 2016.

All these aspects are indicating a big increase in the roads use, and this aspect made the Ministry to search the way to reduce the time response and attention to incidents and accidents in the roads.

After studying different approaches, international experience showed that the best way to increase quality in services to road users is to do maintenance under performance criteria.

Some good examples and case studies were analyzed and all of them showed a performance increase in those parameters perceived by the conventional users as necessary to consider the road network as satisfactory.

CONTRACT FORMAT

As mentioned before, these types of contracts are designed to be awarded for a period from five to ten years, but in this case as is the first experience in our administration for roads maintenance was decided to do a pilot project for two years as first stage of a possible extensions of the same contract.

The TOR of this contract describes the mechanisms to analyze if the contractor performance during the contract and the criteria which will determine if is appropriate to renew it in a period of 2 + 1 years more.

One of the first tasks to be done by the Department is to define the scope of the works to be performed and in what elements performance criteria can be applied.

Regarding the pavements case, the Roads Department still keep the criteria that major maintenance (repair, rehabilitation or reconstruction) will relay in different projects with specific budgets related to awarded contracts (for example rehabilitation for 45Km in two carriageways in Sheikh Mohammed Bin Zayed) or reconstruction of asphalt in 35 km in Dhaid – Masafi road). As can be understood these type of projects will be executed under the umbrella of new contracts apart from the Performance Based one.

To define those elements that were going to be covered by the performance criteria, maintenance activities for the last three years were studied, defining which were the most common elements acting on and which ones had the biggest quantities.

A list of twelve elements to be covered in performance was obtained. Then it was proceeded to create what in the contract are called Technical Specifications (TS).

TS are a compilation of different elements in which performance criteria will be applied. These TS contain some important aspects defining the elements, and the parameters in which performance will be calculated those points are:

- Scope
- Definition
- Level of service
- Response time
- Works to do
- Routine upgrading works (including the time to do the upgrading)
- Considered most common repair activities
- Performance criteria

TS can be then considered as the guideline for the performance works. All those activities are mentioned in the contract as routine maintenance (RM).
From the historical analysis mentioned, those elements showing they had a low frequency of maintenance during the past years or their amount was not that big, will be fixed and maintained under a group called WO. Works will be requested by a formal work order, which will have programs and budgets assigned to those specific works and represent only, the requested jobs.

As a highlight, within the RM group special attention was given to the contract management. This is considered one of the basic parts to be controlled within the Performance mode.

For those elements controlled by performance and having therefore a TS there are two key factors for the contract success.

One is the upgrading time, which is the time granted to the contractor to act in all elements controlled by performance, in order to reach the nominated level of service. To reach a good level of service the contractor should provide a calendar with the works performed per section of each one of the roads in which MoID can identify at any time, what parts of network are still under the period assigned to the upgrading.

Once any element of the roads is upgraded, is considered to be controlled by performance. In that case the calendars will be also the indicators in which the department will base the control for upgrading and performance.

Once the elements are under performance control, time response is a key parameter to be controlled. Delays in this factor originated non-conformity reports that will be the main aspect to consider in the monthly penalty calculation. The other factor causing NCR is the quality of the performed works.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
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<tbody>
<tr>
<td>TS00</td>
<td>CONTRACT</td>
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<td>TS01</td>
<td>PAVEMENTS</td>
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<td>SHOULDERS AND SIDE SLOPES</td>
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<td>TS12</td>
<td>GRAFFITI AND STICKERS REMOVAL</td>
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</tbody>
</table>
During the tender stage two main aspects were evaluated: technical capacity and knowledge of the contract. Both of them had associated the price of the contract, assigned to the monthly performance activities plus the price assigned to a predetermined items contained in the bill of quantities, to work with the work orders mode.

Financial wise the sum of performance works and work orders were considered as the awarded sum for the contract. The performance works will be paid based on a monthly fixed lump sum appointed by the contractor in their proposal which was determined by the knowledge of the technical specifications and the knowledge of the network real situation.

The bill of quantities is based in the prices that the contractor gave to some activities. All of them with assumed assigned quantity assuming that those quantities will be the ones executed during the contract. And based on that the sum of both concepts determined the economical proposal of the tenderers.

From the operational way the incidences for the road can be reported by three means, any user through an 800 telephone number, the MoID inspectors and the contractor inspectors.

To record all incidences a special module in the already existing road assets management system was created. This module contains all the incidences registered in the road.
indicating the time, location, response time, person who reported, associated pictures, etc. This application can be installed in any device controlled by Android or iOS system.

All these incidences will be recorded in the system having three possible status: open, pending and closed. Open activities are those in which the contractor didn’t act still.

Pending will be those activities opened and that can’t be finalized on time due to special circumstances (extreme weather conditions or police incidents). And close, all those activities that are already executed.

**CONTRACT EVALUATION**

A fundamental task in order to know how the contract is performing is the evaluation of the contractor according with the terms of reference contained in the contract.

To control the contractor’s performance according with the contract criteria, the following procedure is applied:

1. Monthly inspections of the roads. The roads are divided in 3 types (A, B or C) depending on their category (A for Highways & Freeways, B for slow speed segments in highways and C for the arterial roads). For each one an inspection will be performed in a minimum certain number of kilometers which will represent the totality of the length of that type of road and will penalize any no compliance for each element detected, in proportional way as if any defect is founded during the inspection.

Minimum inspection in Roads type A should is 40 km, Roads type B 20 km and Roads Type C 15 km. All of them have a certain weight in the system.

2. Aleatory review of closed incidences registered within the system: If any of those incidences is not closed in reality, will mean that it was never closed or as well the incidence was not closed on time after the registration and will create a no incidence.

3. Contract management: as mentioned before is an important part of the system in which documentation, data bases, accidents, environmental aspects are all analyzed and evaluated.

### ROUTINE WORKS

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Task</th>
<th>KPI Ponderation (%)</th>
<th>Detected Non-Compliances</th>
<th>Weighted Non-Compliances</th>
<th>Total of Weighted Non-Compliances</th>
<th>F Final KPI Performance Achievement</th>
<th>Applicable Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>R-A</td>
<td>R-B</td>
<td>R-C</td>
<td>R-A x D</td>
<td>R-B x D</td>
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<tr>
<td>TS01</td>
<td>Pavements</td>
<td>10.00%</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TS02</td>
<td>Shoulders and Sideslopes</td>
<td>5.00%</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TS03</td>
<td>Drainage Structures</td>
<td>10.00%</td>
<td>4.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TS04</td>
<td>Sand Removal</td>
<td>10.00%</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>3.00</td>
<td>0.00</td>
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<tr>
<td>TS05</td>
<td>Fences and Camel Grids</td>
<td>2.00%</td>
<td>22.00</td>
<td>0.00</td>
<td>0.00</td>
<td>22.00</td>
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<tr>
<td>TS06</td>
<td>Lighting</td>
<td>5.00%</td>
<td>4.00</td>
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<td>4.00</td>
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<tr>
<td>TS07</td>
<td>Road Marking</td>
<td>10.00%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>TS08</td>
<td>Guardrails and Safety Barriers</td>
<td>15.00%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TS09</td>
<td>Kerbstones</td>
<td>5.00%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
<td>TS10</td>
<td>Traffic Signs and Road Furniture</td>
<td>12.00%</td>
<td>15.00</td>
<td>0.00</td>
<td>0.00</td>
<td>15.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TS11</td>
<td>Vegetation Control</td>
<td>5.00%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TS12</td>
<td>Graffiti &amp; Stickers Removal</td>
<td>5.00%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**SUBTOTAL** 100.00% 56.00% 74.50% 25.50%
Some extra services will be applied to the contract, as can be immediate attention to accidents whenever police or users require that service cleaning the road and returning the operational conditions again to the traffic.

Another service is the emergency attention. In this case the attention of the contractor will be focused in the instructions given by the corresponding authority. The contractor should help in all situations to solve the requirements of the situation.

All equipment operating in the road will have the Ministry logo and the 24 hour 800 lines for incidences reports on where all incidences received will be registered, followed up and in case is not belonging to the Ministry scope, reallocated with the correct administration.

### PARTIAL RESULTS

Table 1: Results can be Summarized in the Following Actions

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Task Description</th>
<th>Action</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavements</td>
<td>Crack sealing and patching</td>
<td>750m²</td>
<td></td>
</tr>
<tr>
<td>Light poles</td>
<td>Rectification, removal, substitution, re-alignment, operation</td>
<td>840 pieces</td>
<td></td>
</tr>
<tr>
<td>Guardrail</td>
<td>Substitution, removal, rectification</td>
<td>8,400 m</td>
<td></td>
</tr>
<tr>
<td>Signboards</td>
<td>Change, rectification, removal, re-alignment</td>
<td>800 pieces</td>
<td></td>
</tr>
<tr>
<td>Electric feeder pillars</td>
<td>Repair and connection</td>
<td>60 pieces</td>
<td></td>
</tr>
<tr>
<td>Edge fence</td>
<td>Re-alignment, replacement, fixation, removal</td>
<td>3,150 m</td>
<td></td>
</tr>
<tr>
<td>Camel grids</td>
<td>Cleaning, replacement, removal</td>
<td>25 pieces</td>
<td></td>
</tr>
<tr>
<td>General cleaning</td>
<td>Carriageway</td>
<td>45 Km</td>
<td></td>
</tr>
<tr>
<td>Sand removal</td>
<td>From carriageway and fences</td>
<td>6,100 m</td>
<td></td>
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<tr>
<td>Concrete barriers</td>
<td>Repair, re-alignment and removal</td>
<td>15 pieces</td>
<td></td>
</tr>
<tr>
<td>Plastic delineators</td>
<td>Replacement</td>
<td>38 pieces</td>
<td></td>
</tr>
<tr>
<td>Light cable</td>
<td>Removal and replacement</td>
<td>525 m</td>
<td></td>
</tr>
<tr>
<td>Emergencies</td>
<td>Removal of water accumulation</td>
<td>16,000 m³</td>
<td></td>
</tr>
<tr>
<td>Emergencies</td>
<td>Shoulders scouring repair</td>
<td>100 m³</td>
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</table>
Figure 8: Economic Performance we can Represent the Last Months as per the Control Chart

CURRENT AND FUTURE EXPECTATIONS FOR THIS CONTRACT

The most important activities for the rest of 2017 in this contract are as follows:

- Road marking 7000 km of road lines & 3500 road marks
- Measurement of 2700 signboards retro reflectance values
- Culverts cleaning for storm prevention
- Physical inventory of all elements of the network considering useful information from the RAMS and the inspections for each one of these elements contained on it. As well determining the asset assessment condition index

Activities for next year (2nd of contract) will be:

- Maintenance of the levels of service
- Suggestions for improving the safety conditions (along road safety audits)
- Suggestions to improve the ITS network in the Ministry

The future conditions of these type of contracts are related to contain more elements within the performance format as for example:

- Pavements condition
- Bridge condition
- Slopes condition
- Protocols to improve accidents registration with the road safety audits to be performed

CONCLUSIONS

Performance Based Contracts are an efficient way to make progress in road maintenance. The decision to implement this type of contract is a step ahead in the management of the contracts in the MoID.

Not only because allows to relay the good conditions of the elements to be controlled and maintained in the company in charge, but, because this maintenance has to comply quality conditions, fast response and excellent services to the users, better attention to accidents and support for police and civil defense corps.

The improvement on the contract activities is now evident and the expectation for the economic development can be predicted as successful due to the partial results and evolution of the activities.

Is expected to renew this contact and implement more of this type for different scopes in the Ministry. Some of the most important technical conditions for the implementation of PPP contracts are now established at least for roads maintenance and from this contract structure some others can be written.
# IRF EXECUTIVE COMMITTEE

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Kingdom of Saudi Arabia

## Vice Chairmen (2017 - 2019)
<table>
<thead>
<tr>
<th>Name</th>
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<tr>
<td>Jeffrey R. Reed</td>
<td>Valley Slurry Seal Company</td>
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<tr>
<td>T. Peter Ruane</td>
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<tr>
<td>Thomas Topolski</td>
<td>LB International</td>
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## Treasurer (2017 - 2019)
Lester Yoshida  
Parsons

## President & CEO and Secretary
C. Patrick Sankey  
International Road Federation

## Elected Directors to Serve on Executive Committee (2016 - 2017)

<table>
<thead>
<tr>
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<tr>
<td>Tarek Al-Shawaf</td>
<td>Saudi Consulting Services</td>
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<tr>
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## IREF Chairman (2014 - 2018)
Essam Radwan  
University of Central Florida

## DIRECTORS (2015 - 2017)

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**Note:**  
* Denotes Ex-Officio Member

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