Innovative Systems Design and Engineering
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol.4, No.13, 2013

Road Deterioration from Client and Contractor perspectives

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ABSTRACT

Pavement deterioration is a critical issue for roads and highways in Jordan, because of difficulty in determination the causes for defects and cracks. The budgeted cost for construction, replacement and rehabilitation, and maintenance of roads was 484.3 M JD in the implementation programs for the period from 2007 to 2013. The current research aims to describe the highly related causes for road deterioration in Jordan by a questionnaire designed and directed to contractors and clients in road construction and maintenance, and to study the difference between clients and contractors' perspective and ranking for causes of road cracks and deteriorations individually and in groups.

A list of causes was prepared through literature review, consulting and interviewing a group of 30 managers from contractors and experts clients in the field of road construction and maintenance, they advised to study 51 of expected causes for road deterioration. Then a questionnaire was directed to 150 of contractors and 150 of clients in road construction and maintenance. The mission was involving to give a scale (rank) from 1 (strongly disagree), 2 (disagree), 3 (do not know), 4 (agree), and 5 (strongly agree) to the expected causes. 38 (25.33%) of contractors' responses and 47 (31.33%) of clients' responses were received and analyzed. According to the contractors ranking, the criterion (defects caused during construction due to poor construction quality) takes the highest rank of 4.15, while the lowest factor is (inadequate resistance to polishing of surface aggregate) of 2.73. While according to the clients ranking, the criterions poor highway facilities, poor maintenance policy / culture, large axial traffic loading took the highest rank of 4.13, 4.1, and 4.09 respectively. While the lowest rank was for ground water level of 2.964 according to clients rank. The clients and contractors seem to be different individually by 80.4% and 100% in groups of factors by doing the test statistics for difference in means considering confidence interval of 10%. The research is focusing on road deterioration causes and helpful contractors and clients in Jordan in roads and highways design, construction, and maintenance and for effective engineering operation in road and highway sector in Jordan.

Keywords: Deterioration, defects, road construction, road maintenance, highway

1. INTRODUCTION

Road construction and maintenance is an important desire for development especially in developing countries. Market accessibility, economic growth, natural resource exploitation, habitat fragmentation, deforestation, and the disappearance of wild lands and wildlife are all related to road existence and status. Road constructed and maintained that collapsed upon the need of local society and their extension in country. Also the priority of investment (political needs, industrial stations, or agricultural habitats and zones) is addressed when decision usually taken for new construction of road and for maintenance (Wilkie et.al. 2000).

Road transport is the moving engine for other sectors and activities in development countries. It provides access to industry, agriculture, investment, health services, and education through providing of goods and passengers. The lack for good roads or the existence of poorly maintained or poor conditions of roads are barriers to development and investment in developing countries. In Jordan the cost for road construction and maintenance consumed about 292.1 M JD in the implementation program (2007-2009) and about 192.2 in (2011-2013).

The cost for inspection of road status is very high, complicated operation, and unsafe for working team especially on major roads and main routes. Also the visual inspection by map is not accurate only but for small scale range. There is a strong relation between the ground spectrometry, imaging spectrometry, and in situ pavement conditions and quality indicators (pavement condition index). Road aging, and material composition (defects and cracks and status of material) is related to spectral characteristics of road section that enable from mapping road conditions. Pavement condition of aging and erosion of the hot mix asphalt results in a gradual change from hydrocarbon to mineral absorption characteristics, with a general increase in brightness and changes

in distinct small-scale absorption features. Structural road damage (e.g., cracks) indicates a contrary spectral variation. Cracking decreases the brightness and emphasizes hydrocarbon absorption features. The spectrometry testing is more sensitive and useful on new roads of early stages of deterioration rather than on old roads (Herold and Roberts, 2005).

The accurate and sensitive prediction of rutting development is an essential element for the efficient management of pavements systems by proper testing and maintenance to keep road in a good condition. Road defects are the visible evidence of an undesirable and avoidable condition in the pavement affecting serviceability, structural condition or appearance, performance and function. Also, the definition of "road defect" includes any part of a road, highway, or construction site that does not meet the regulations for a safe road. In addition to that; road defects are the most often cause injuries to people or damage to vehicles that include: inadequate road shoulders, lanes that are uneven, pavement that is uneven, improperly marked signs, malfunctioning stop lights, construction negligence, and municipal negligence (Okikbo, 2012).

Kaare, Kuhi and Koppel (2012) pointed that flexible pavement deteriorates under the effect of traffic loads and climate. This effect depends on the technology applied in material construction and application on the road, but the greatest effects depend on traffic loads and volumes proposed to be repeated on road section. Abhijit (2011) investigated the effect of poor drainage on road condition and found that the increase in moisture content decreases the strength of the pavement. Therefore, poor drainage causes the premature failure of the pavement. On the same line, pavement tends to crack at some point of their life under the combined action of traffic and the environment and climate conditions (Wee et. al., 2009). Wisconsin Department of Transport investigates the pavement fatigue as a result of the number and weight of axle loads. They also discusses how wheel loads, number of truck axles, number of truck tires, quality of sub-grade, pavement thickness and changing seasons contribute to pavement fatigue.

In addition, climate conditions were seen to have an effect on road deterioration, vehicle operating costs, road safety and the environment (Anyala et.al. 2011). Transport Canada (2005) indicated that climate factors are a major cause for pavement deterioration. It is a fact that temperature, frost and thaw action as well as moisture are factors that can cause certain types of pavement deterioration (Transport Canada, 2005). These factors can also intensify pavement deterioration caused by heavy vehicles.

Harischandra (2004) found that potholes, cracks, edge defects, depressions and corrugation are significant road defects observed in the field. At the same time he emphasized that traffic, age, road geometry, weather, drainage, construction quality as well construction material, maintenance policy play the major role as road deteriorate agents. Korkiala-Tanttu and Daeson (2007) suggested that in the pavement or embankment, water plays a primary role in giving shorter service life and in increasing the need of rehabilitation measures.

Abdulkareem and Adeoti (2004) examined the method of road maintenance in Nigeria. To do so, they defined and analyzed the causes of structural failure of highway pavement and suggest some factors; action of weather, rain and heat, unstable ground conditions and poor drainage, poor construction material and methods, post construction activities like digging of trenches along the road etc., poor workmanship and inadequate maintenance. On his study on Nigeria highway, Okido (2012) has indentified some of the factors that cause highway failure. These factors were; poor design and construction, poor maintenance of already built highways, use of low quality materials in construction, poor workmanship and poor supervision of construction work and the applying of heavy traffic that were not meant for the road. Furthermore, he also suggest that the following will lead to highway failure such as; poor highway facilities, no knowledge base, in adequate sanction for highway failure, no local standard of practice, poor laboratory in situ tests on soil and weak local professional bodies in highway design, construction and management.

It is obvious that roads globally deteriorate for several reasons. Roads and highways in Jordan are not exception, and deteriorate under the effect of the same reasons. So, the recognizing of causes for cracks and deterioration in road system is the first step in putting successful maintenance program that will keep roads and highways in good conditions. A concentrated literature review explored a list of 51 of causes for cracks and deterioration that were studied from contractors' perspective (Tarawneh and Sarireh, 2013) and currently studied from client perspective recalling results from contractors and clients perspective.

The current research aims in identifying the proposed factors that cause the deterioration of highway in Jordan from client perspective comparing them with the contractors' perspective and establishing their relative importance for the use by consultants and main road contracting firms. A questionnaire was designed including the 51 factors to examine these factors and ascertain their important index from client's perspective.

The current research highlights the factors for cracks and defects in highways and roads in Jordan from clients' perspective and comparing them with contractors' perspective (Tarawneh and Sarireh, 2013). The work will help in prioritizing the relevant importance for these factors to improve the programs for effective maintenance and surveying defects of highways and roads in future.

1. RESEARCH METHODOLOGY

Current research mainly highlights the factors proposed to have an effect on the highway pavement performance. Based on previous studies and face-to-face interviews for Jordanian firms in road construction, a list of 51 factors were listed to have an effect on pavement performance and defects according to researchers and contractors in road construction. A questionnaire was prepared including these factors for road cracks and defects. The prepared questionnaire was initially presented to a group of experts in questionnaire preparation. Instantaneously, the proposed 51 factors which were recommended to cause pavement deterioration reviewed by 15 individuals; 5 of each party involved in a highway project construction and maintenance, i.e., from clients, consultant and contractors firms.

The final copy of the questionnaire was sent out to 150 respondents selected from a pre prepared list of experienced engineers from main clients and operational firms in Jordan. The final step is to analyze the priority (importance) of the 51 factors according to the ranking given to these factors (from 1 to 5) by clients, and then comparing them with contractors ranking conducted in previous research.

2. PROCEDURES AND DATA COLLECTION

A sampling frame was prepared of clients and operators for traffic highways and roads in Jordan including engineers in The Ministry of Public Works and Housing, Ministry of Municipalities, and directories of Municipalities Engineering. In addition to the consultation conducted with The Jordanian Association for Construction Contractors. The aim was to generate a list of (150) respondents who were involved in the operation of the construction and maintenance of roads. The list includes one key or senior manager from each of the top 150 Jordanian engineers and superintendents in clients and operators' firms specialized in operation of road construction and maintenance.

To compensate the lack of information and knowledge for respondents, an in depth literature review and in face-to-face interview was taken as the main instruments to recognize the list for deterioration factors. Also an initial interview was done through interviewing 5 construction firms selected randomly to have the initial perception about the research aim and methodology.

Then, a questionnaire was prepared for collecting data in parallel to the deep literature review and consultation with 15 Jordanian construction firms (5 contractors, 5 clients, and 5 consultants). The designed questionnaire was reviewed with the same consultancy group i.e. 15 construction firms. The questionnaire includes information about the research aim and procedure that will be followed in the questionnaire. Then the questionnaire was sent to the selected 150 experienced personnel from the clients and operators' firms in Jordan.

Finally, the collected data was reviewed with the consultancy group against satisfaction of aim and methodology to start analysis for the importance given for factors of cracks and deterioration for highways and roads in Jordan according to clients' perspective.

3. RESULTS OF CLIENT ROAD DETERIORATION

A sample of 150 personnel of managers, engineers, designers, supervisors, and superintendents were selected randomly in clients and operators' in engineering firms and institutions that include Ministry of Public Works and Housing, Ministry of Municipalities' Affairs, The Directories of Municipalities Engineering.

A 47 of respondents from clients and operators' firms and institutions were received out of 150 questionnaire sent to those personnel that forms 31.33% as a response rate that is presented in Table 1.

Table 1 Frequency and Ratio of Clients Respond

Experience (Years)	Frequency of Responses	% of Responses
2 to 5	5	10.64
6 to 9	11	23.40
10 to 13	14	29.79
14 to 17	5	10.64
> 18	12	25.53
Sum	47	31.33

4. Road Deterioration Individual Factor Ranking

The questionnaire includes the 51 factors related to road deterioration that were ordered randomly. Clients and operators personnel responded by giving a scale from 1 (strongly disagree), 2 (disagree), 3 (not known), 4 (agree), 5 (strongly agree) to these factors depending on their experience for expecting the importance of a specific factor for road deterioration. Then the weighted average was calculated for each factor using contractor's given response scale (from 1 to 5) and client's personnel experience using the following equation.

$F_{average} = (\sum F_i \times X_i) / \sum X_i$ Equation (1)

Where $F_{average}$ is the calculated average for the factor of deterioration and indicated as individual rank, F_i is the rank (from 1 to 5) given to the factor of deterioration by client's personnel in the questionnaire, and X_i is the experience in years for the client's personnel.

Then the client's group factors is calculated by taking the average of factors covered under one group and factors ($F_{average}$) are related to each other; thickness group factors, traffic group factors, architecture group factor, etc.

A comparative step between client individual factor rank and contractor individual factor rank will be conducted on the means of both ranks given by client and contractor using the inference about the different in means, randomized design or simple comparative experiment. Following equations explain the procedure that will be applied in the calculations and results sections.

$H_O : \mu_1 = \mu_2$ using test statistic $Z_O = = \frac{\bar{y}1 - \bar{y}2}{\sqrt{\frac{\delta 1^2}{n1} + \frac{\delta 2^2}{n2}}}$, the rejection of hypothesis if $|Z_o| > Z_{\alpha/2}$, where:

μ_1 and μ_2 are the means in the null hypothesis H_O that were replaced by the two averages $\bar{y}1$ and $\bar{y}2$ for factor ranking given by the client and contractor respectively, $\delta 1^2$ and $\delta 2^2$ are the variance for factor ranking given by the client and contractor, n_1 and n_2 are the number of clients' and contractors' samples respectively, α is the confidence interval of 10% considered, and $Z_{\alpha/2}$ is the number of standard normal distribution in the cumulative standard normal distribution tables at the confidence interval $\alpha/2$ which is 5% here (Walpole et.al., 2007).

4.1 CLIENT INDIVIDUAL RANKING

The mean of client individual ranking for factors of cracks and deterioration on highways and roads in Jordan are illustrated in Table 2 in a descending order, in addition to contractor's individual factor rank for the respective factor in client factor rank. According to the client ranking, it seems that Poor Highway Facilities, Poor Maintenance Policy/Culture, Large Axial Traffic Loading, and Poor Supervision take the highest rank of 4.13, 4.10, 4.09, and 4.07 respectively. While, Stone deterioration, Ice and Snow, and High Ground Water Level have the lowest rank of 3.19, 3.08, and 2.96 respectively. After applying the statistical comparison between the mean of client rank and the mean of contractor rank for the factors of cracks and deterioration, the results are presented in Table 2 in the last column. The Table results show that clients and contractors are inconsistent and disagree on 41 of the factors for cracks and deterioration to have the same (equal rank) or importance level, while they are agree on 10 of those factors for cracks and deterioration.

Table 2 Client's Factor Rank for Road Deterioration and Statistical Comparison with Contractor's Factor Rank

Cause for Cracks and Road Deterioration	Client Individual Rank	Contractor Individual Rank*	Means' Test Statistics
Poor highway facilities	4.13	4.00	$\mu_1 = \mu_2$
Poor maintenance policy / culture	4.10	3.84	$\mu_1 = \mu_2$
Large axial traffic loading	4.09	3.62	$\mu_1 \neq \mu_2$
Poor supervision	4.07	3.92	$\mu_1 = \mu_2$
Defects caused during construction due to poor construction quality	4.05	4.15	$\mu_1 \neq \mu_2$
Inadequate compaction in surfacing or sub / base	4.04	3.49	$\mu_1 \neq \mu_2$
Shrinkage & binder oxidation in AC or sprayed surfacing due to effect of age and environment	4.04	3.07	$\mu_1 \neq \mu_2$
Poor drainage design system	4.01	3.31	$\mu_1 \neq \mu_2$
Inadequate base thickness	3.98	3.22	$\mu_1 \neq \mu_2$
Inadequate cleaning or inadequate tack coat before placement of upper layers	3.97	3.55	$\mu_1 \neq \mu_2$
Fatigue cracking of AC wearing course	3.95	3.39	$\mu_1 \neq \mu_2$
Poor material quality on sub / base layers	3.95	3.2	$\mu_1 \neq \mu_2$
Poor local standard of practice	3.94	3.75	$\mu_1 = \mu_2$
Inadequate sanctions for highway failure	3.94	3.73	$\mu_1 \neq \mu_2$
Reflection of a shrinkage crack or joint in an underlying base	3.93	3.81	$\mu_1 = \mu_2$
Inadequate compaction, construction during wet or cold weather	3.92	3.46	$\mu_1 \neq \mu_2$
Poor laboratory and in situ tests on soil	3.91	3.73	$\mu_1 \neq \mu_2$
Low stiffness base and poor material	3.91	3.61	$\mu_1 \neq \mu_2$
Poor bond between pavement layers	3.88	3.20	$\mu_1 \neq \mu_2$
Inadequate pavement thickness	3.88	3.32	$\mu_1 \neq \mu_2$
Shrinkage & fatigue of brittle base or wearing course	3.88	3.55	$\mu_1 \neq \mu_2$
Poor alignment of the road	3.87	3.36	$\mu_1 \neq \mu_2$
Structural failure of base	3.86	4.01	$\mu_1 \neq \mu_2$
Hydrophilic aggregate	3.84	3.28	$\mu_1 \neq \mu_2$
Seepage of water through asphalt to break bond between surface and lower layers	3.84	3.92	$\mu_1 = \mu_2$
Inadequate edge support	3.83	2.80	$\mu_1 \neq \mu_2$
Inadequate sub base thickness	3.82	2.98	$\mu_1 \neq \mu_2$
Low binder content	3.81	3.19	$\mu_1 \neq \mu_2$
Large traffic volume using the road	3.78	3.56	$\mu_1 = \mu_2$
Deterioration of binder and / or stone	3.78	3.46	$\mu_1 \neq \mu_2$
Inferior asphalt mix design	3.78	3.53	$\mu_1 \neq \mu_2$
Inadequate strength (stability) in surfacing or base	3.75	3.40	$\mu_1 \neq \mu_2$
Inadequate pavement width	3.74	2.95	$\mu_1 \neq \mu_2$
Lack of containment of pavement edge	3.74	3.26	$\mu_1 \neq \mu_2$
Low knowledge base	3.73	3.20	$\mu_1 \neq \mu_2$
Inadequate rolling before opening to traffic	3.71	3.48	$\mu_1 \neq \mu_2$
Poor geometric design of the road	3.71	3.05	$\mu_1 \neq \mu_2$
Weak seal coat, loss of adhesion to base	3.69	3.52	$\mu_1 = \mu_2$
Construction joint or shrinkage crack (due to low temperature or bitumen hardening) in asphalt surfacing	3.67	3.87	$\mu_1 \neq \mu_2$
Aging or absorption of blinder	3.64	3.41	$\mu_1 \neq \mu_2$
Incorrect blending of binder	3.60	3.08	$\mu_1 \neq \mu_2$
Weak, loose layer immediately under laying seal	3.60	3.90	$\mu_1 \neq \mu_2$
Poor blinder to stone adhesion	3.57	3.16	$\mu_1 \neq \mu_2$
Edge Drop-off	3.55	3.06	$\mu_1 \neq \mu_2$
Alignment which encourages drivers to travel on pavement edge	3.54	3.23	$\mu_1 \neq \mu_2$
Poor climate condition	3.38	3.64	$\mu_1 \neq \mu_2$
Inadequate resistance to polishing of surface aggregate	3.33	2.73	$\mu_1 \neq \mu_2$
Use of naturally smooth uncrushed aggregate	3.31	3.18	$\mu_1 = \mu_2$
Stone deterioration	3.19	3.40	$\mu_1 \neq \mu_2$
Ice and snow	3.08	3.57	$\mu_1 \neq \mu_2$
High ground water level	2.96	2.90	$\mu_1 = \mu_2$

***Contractor Individual Rank (Tarawneh and Sarireh, 2013)**

Table 3 presents some statistical descriptions for the client factors' rank on road deterioration, it has 31 (61%) of factors above the mean, 12 (23.53%) above the mode, and 25 (50%) above the median, and standard deviation of 0.259.

Table 3 Statistical Parameters for Client Factor Rank on Road Deterioration

Statistical Parameter	Value	Factors > Value
Mean	3.770	31 (61%)
Mode	3.9374	12 (23.53)
Median	3.833	25 (50%)
Standard Deviation	0.259	
Sample elements (n)	51	

4.2 CLIENT GROUPED RANKING

Individual factor rank for cracks and deterioration given by the clients and operators of highways and roads in Jordan can be grouped together in specific groups depending on relations between these factors and according to the recommendations of the experts consulted in this research. Table 4 presents the group of effect of standards/specifications and policy, the group scores 3.975 which is the average of factors in the group.

Table 4 Group of Eff4ect of Standards/Speccifications and Policy in Client's Factor Rank

Effect of Standards/Specifications and Policy		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Low knowledge base	3.732	3.975
Poor highway facilities	4.130	
Inadequate sanctions for highway failure	3.940	
Poor local standard of practice	3.940	
Poor supervision	4.070	
Poor laboratory and in situ tests on soil	3.911	
Poor maintenance policy / culture	4.100	

Table 5 presents the Effect of traffic load and volume group, the group ranks 3.936, and the group is interested in the capacity of traffic and the volume of traffic. It seems the traffic load and volume have a high priority for clients and operators.

Table 5 Traffic Load an`d Volume Group in Clent Rank

Effect of Traffic Load and Volume		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Large axial traffic loading	4.090	3.936
Large traffic volume using the road	3.781	

Table 6 presents the Effect of flexible pavement layers' thicknesses, the group ranks 3.893, and the group includes thickness of pavement's layers. Even though the design can control the thickness of layers, but clients still see the issue of material thickness is highly important.

Table 6 Flexible Pavement Layers' Thicknesses in Client Rank

Flexible Pavement Layers Thickness		
Cause Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Inadequate pavement thickness	3.880	3.893
Inadequate base thickness	3.980	
Inadequate sub base thickness	3.82	

Table 7 presents the group of cracks and structural failure, the group ranks 3.877 and related to reflection of cracks, construction joints, failure in base, and defects during construction.

Table 7 Group of Cracks and Structural Failure in Client Rank

Effect of Cracks and Structural Failure		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Reflection of a shrinkage crack or joint in an underlying base	3.930	3.877
Construction joint or shrinkage crack (due to low temperature or bitumen hardening) in asphalt surfacing	3.669	
Structural failure of base	3.86	
Defects caused during construction due to poor construction quality	4.050	

Table 8 presents the group of Compaction and Construction, the group ranks 3.855 and related to compaction and construction of sub-base and base layers and weather conditions during construction.

Table 8 Effect of Compaction and Construction

Compaction and Construction		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Inadequate compaction in surfacing or sub / base	4.040	3.855
Inadequate strength (stability) in surfacing or base	3.745	
Inadequate compaction, construction during wet or cold weather	3.920	
Inadequate rolling before opening to traffic	3.713	

Table 9 presents the Effect of Bond between Layers group, the group ranks 3.721, and the group represents bond between layers, surface contact of bitumen, and aggregate and filler material.

Table 9 Effect of Bond Between Layers

Effect of Bond Between Layers		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Poor bond between pavement layers	3.881	3.721
Low binder content	3.810	
Poor blinder to stone adhesion	3.571	
Incorrect blending of binder	3.603	
Aging or absorption of blinder	3.643	
Weak seal coat, loss of adhesion to base	3.686	
Weak, loose layer immediately under laying seal	3.600	
Inadequate cleaning or inadequate tack coat before placement of upper layers	3.970	

Table 10 presents the group of Effect of Pavement Width that ranks 3.715 at the last rank of all groups. It should not be a point of discussion that should the pavement width greater than the width of vehicle plus a separate space, or should the pavement have an enough support edge, or should the pavement have enough shoulders or embankment.

Table 10 Effect of Pavement Width

Effect of Pavement Width		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Inadequate pavement width	3.741	3.715
Inadequate edge support	3.833	
Edge drop-off	3.546	
Lack of containment of pavement edge	3.740	

Table 11 presents the group of Alignment and Geometry of Road that ranks 3.706. The geometry and alignment of road is important to protect the surface and section of the road. The elements of geometry and alignment should be met during design phase of highway.

Table 11 Effect of Alignment and Geometry of Road

Effect of Alignment and Geometry of Road		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Alignment which encourages drivers to travel on pavement edge	3.537	3.706
Poor alignment of the road	3.870	
Poor geometric design of the road	3.710	

Table 12 presents Asphalt Cement (AC) Properties and Effect of Construction Conditions. The content of bitumen in the flexible pavement has two issues: the first is the quantity of AC, and the second is the weather conditions that should be faced by improving the properties of bitumen.

Table 12 Effect of AC Properties and Construction Conditions

AC Properties and Effect of Construction Conditions		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Shrinkage & fatigue of brittle base or wearing course	3.875	3.665
Fatigue cracking of AC wearing course	3.953	
Shrinkage & binder oxidation in AC or sprayed surfacing due to effect of age and environment	4.035	
Poor climate condition	3.382	
Ice and snow	3.082	

Table 13 presents the group of Aggregate Properties, the group has the rank of 3.635, the group also presents the strength and soundness of aggregate, which is function of stone origin or type, such as crushed limestone or round natural aggregate.

Table 13 Effect of Aggregate Properties

Effect of Aggregate Properties		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Stone deterioration	3.185	3.635
Low stiffness base and poor material	3.908	
Poor material quality on sub / base layers	3.950	
Deterioration of binder and / or stone	3.778	
Hydrophilic aggregate	3.844	
Inadequate resistance to polishing of surface aggregate	3.334	
Use of naturally smooth uncrushed aggregate	3.306	
Inferior asphalt mix design	3.777	

Table 14 presents the Effect of Drainage System and Ground Water, the group ranks 3.625. Road deterioration in some cases is due to the accumulation of water on road surface that seeps into pavement layers, because of inadequate drainage system, and/or because of the absence of sectional, and/or longitudinal slopes.

Table 14 Effect of Drainage System and Ground Water

Effect of Drainage System and Ground Water		
Cause of Road Cracks and Deterioration	**Client**	
	Individual	**Group**
Poor drainage design system	4.070	3.625
Seepage of water through asphalt to break bond between surface and lower layers	3.840	
High ground water level	2.964	

4.3 Summary of Grouped Deterioration Factor of Client and Contractor Response

Table 15 presents the rank for the group factor of client response at road deterioration. The effect of standards/specifications and policy has the maximum rank of 3.975, while the effect of drainage system and ground water has the minimum ranks of 3.625. The clients see that the standards and specifications are important to be considered in design and construction and have an effect on deterioration in road section as designer will apply the minimum requirements for design and construction. Also, the table presents the relevant contractor group factor respectively. Another important point of view that by conducting the difference in means of clients and contractors group factor, the test statistics gives that the means are different in group comparison.

Table 15 Grouped Deterioration Factor of Client and Relevant Contractor Grouped Factor

Road Deterioration Factor Group	Factors' Number in Group	Client Group Rank	Contractor Group Rank*	Group Mean Test Statistics
Standards/Specifications and Policy	7	3.975	3.71	$\mu_1 \neq \mu_2$
Traffic Load and Volume	2	3.936	3.59	$\mu_1 \neq \mu_2$
Flexible Pavement Layers Thickness	3	3.893	3.14	$\mu_1 \neq \mu_2$
Cracks and Structural Failure	4	3.877	3.96	$\mu_1 \neq \mu_2$
Compaction and Construction	4	3.855	3.46	$\mu_1 \neq \mu_2$
Bond Between Layers	8	3.721	3.43	$\mu_1 \neq \mu_2$
Pavement Width	4	3.715	2.93	$\mu_1 \neq \mu_2$
Alignment and Geometry of Road	3	3.706	3.21	$\mu_1 \neq \mu_2$
AC Properties and Construction Conditions	5	3.665	3.41	$\mu_1 \neq \mu_2$
Aggregate Properties	8	3.635	3.24	$\mu_1 \neq \mu_2$
Drainage System and Ground Water	3	3.625	3.38	$\mu_1 \neq \mu_2$
	51 Factors	Mean = 3.782	3.43	$\mu_1 \neq \mu_2$

***Contractor Group Rank (Tarawneh and Sarireh, 2013)**

5. DISCUSSION AND CONCLUSIONS

The study aims to introduce the perspective and vision of the parties of road construction (mainly, the clients and the contractors). Both parties have different interests and areas to be considered during design, construction, and operation and maintenance. According to the client ranking, it seems that Poor Highway Facilities, Poor Maintenance Policy/Culture, Large Axial Traffic Loading, and Poor Supervision take the highest rank of 4.13, 4.10, 4.09, and 4.07 respectively. While, Stone deterioration, Ice and Snow, and High Ground Water Level have the lowest rank of 3.19, 3.08, and 2.96 respectively.

While according to contractors rank of individual factors, it seems that the factor (Defects caused during construction due to poor construction quality) takes the highest rank of 4.15, followed by the factor (Structural failure of Portland cement concrete base) that takes 4.01, and poor highway facilities of 4 as the

maximum 3 factors that came at the top causes for road deterioration. The lowest factor rank is (Inadequate resistance to polishing of surface aggregate) of 2.73 in the contractors' individual rank.

By testing the difference in means of individual ranks of factors studied by contractors and clients respectively, both parties are agree on ten of the factors (Poor highway facilities, Poor maintenance policy / culture, poor supervision, Poor local standard of practice, Large traffic volume using the road, Seepage of water through asphalt to break bond between surface and lower layers, Reflection of a shrinkage crack or joint in an underlying base, Seepage of water through asphalt to break bond between surface and lower layers, and Weak seal coat, loss of adhesion to base. While, were different in the rest of the 41 individual factors.

Also, considering the difference in means of the grouped rank of factors, the clients are different from contractors in the grouped rank factors. The result is consistent with the result in the individual factor rank as both parties are 80.4% (41/51) differs or deviate from each other during road design, construction, and maintenance.

The clients have interests differs from contractors during design (specifications and standards, tests, and cost). Also, they have different interests during construction including specifications, supervisions, cost, material properties, and adequacy of structure design and performance). Because of the difference of interests between clients and contractors, the need appears for a mediator such as an engineer or/and consultant to have the mission of quality control and quality assurance and to close the gap between two parties.

6. RESEARCH LIMITATIONS

Even though, the current research has useful results for the parties of road construction and maintenance, the research has some faults and shortcomings:

1- Even the confidence of information and data are guaranteed, not all clients and contractors accept to give personal or/and subjective information and data about their perspective in the topic.
2- Responds came from different geographic regions in Jordan that makes some factors related to materials properties; soil conditions; weather conditions; and ground water level are not consistent to be the reason for cracks and defects of road and highways in Jordan.
3- The need for geographical and detailed study is required to cover the difference in materials and soils, and weather conditions and ground water clearly.

AKNOWLEDGEMENT

The authors would like to grant their thanks for clients and operators of construction and maintenance of highways and roads in Jordan including the ministry of public works and housing, ministry of municipalities, directory of municipalities engineering for supporting and facilitating of our mission in this research.

Also, thank is granted for contractors supported and participated in the research by participation in designing and reviewing the questionnaire, by providing data, doing consultations and evaluation of results.

Thanks is an owe for our colleagues in the departments of civil engineering in Mu'ta University and Tafila Technical University for their support and help during conducting the study by saving our time and good wishes for us.

Grate thanks for our families for their patience and support during researching, writing, and reviewing daily in continuous long days and nights.

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