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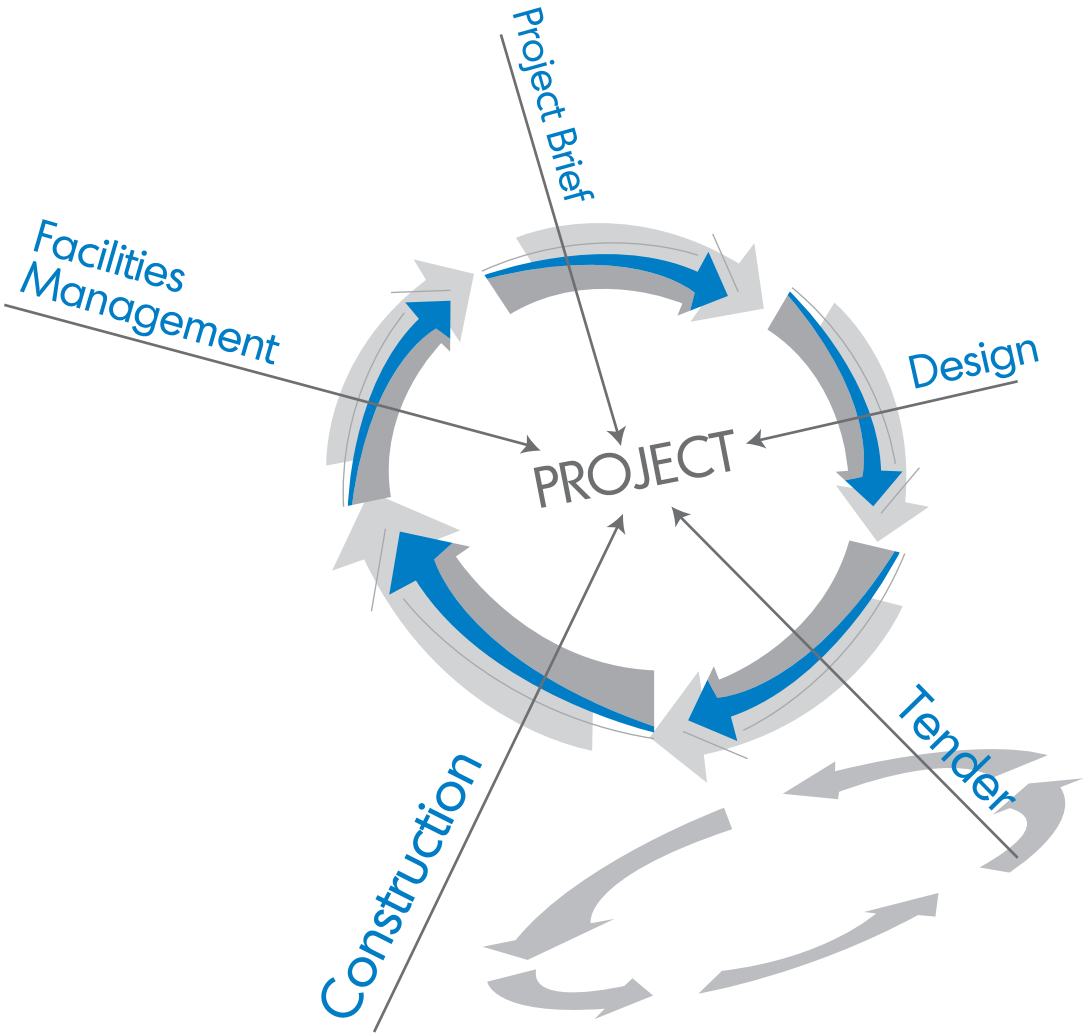

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Editorial

Welcome from the Editors

Welcome to the twelve issue of Malaysian Construction Research Journal (MCRJ). The editorial team would like to extend our gratitude to all authors and reviewers for their continuous contributions and valuable comments. It is hope that the readers will find beneficial information from this edition of MCRJ. 6 papers are discussed in this issue.

Seyed Jamal Aldin Hosseini and Ahmad Baharuddin Abd. Rahman, shows the results of experimental tests on splice connectors joining two main steel bars by using connected steel bars confined by the grouted sleeve connectors. A total of 21 grouted splice connectors were tested until failure under increasing axial load. Each sleeve connector consisted of steel pipe, steel spiral with vertical bars and cement grout. The key parameter was the diameter of the spiral reinforcement which confined the splicing of two steel reinforcement bars. The effects of spiral diameter of 35, 45, 55, 65, 75 and 85 mm on the bond strength and slip were critically investigated. The test results indicate that specimens with smaller spiral reinforcement accompanied by four shear keys provide greater bond strength. The improvement in bond strength is due to the confinement provided by the spiral reinforcement which eventually increases the axial tension capacity of the sleeve connector.

Meor Othman Hamzah, et. al., review the effects of geometrically cubical shape aggregates on the resilient modulus, creep stiffness and resistance to rutting of asphaltic concrete by concentrates on the effects of incorporating various percentages of Geometrically Cubical Shaped (GCS) aggregate in the asphaltic concrete on volumetric properties, resilient modulus, creep stiffness and resistance to rutting. Two different aggregate blends of normal shaped aggregate and GCS aggregate were used to prepare five different percentages of GCS aggregate, designated as Mix M0, M25, M50, M75 and M100. Mix heights were recorded during compaction to evaluate workability. The engineering properties of the mixes were determined from the resilient modulus, creep stiffness (dynamic creep) and resistance to rutting (immersion wheel tracking) tests. The results shows incorporation of GCS aggregate has significant effects on workability index, resilient modulus, creep stiffness and resistance to rutting of asphalt specimens.

Faisal Zulhumadi, et. al., discuss the construction supply chain management practices in Malaysia through the findings of a Construction SCM (CSCM) study from the Malaysian construction perspective. The main objectives of this study were to identify the SCM practices, and to explore the level of adoption and practice of these identified SCM practices in the Malaysian construction industry by using a mixed-mode method through structured questionnaires and interviews

with the main construction industry players, namely the contractors, developers, and suppliers. The results were framed against the Strategic Thrusts as provisioned by the Construction Industry Master Plan (CIMP) as released by the Construction Industry Development Board (CIDB).

A.R. Abdul-Aziz, et. al., encourage an export of Malaysia's construction professional services such as architectural, civil engineering and quantity surveying firms from the certain internationalisation aspects – internationalisation motivations, firm-specific advantages, home country-specific advantages, location factors and methods of securing overseas work – of the sampled firms using the quantitative-qualitative combination of postal questionnaire survey and interviews. It was found that top management decision was the main internationalisation motivation and also adds to our knowledge on the internationalisation of services firms which is inadequate compared to manufacturing firms. Studies on multinational firms from developing countries are rare.

Oluwayomi Kayode Babatunde and Sui Pheng Low, investigate the ISO 9000 Quality Management System (QMS) in Nigeria to gauge the readiness for Total Quality Management (TQM). This study is limited to ISO 9000 QMS and TQM as two possible management tools for Quality Management (QM) in Nigeria; future researches can investigate other forms of QM in Nigeria. Practical implications of the study include improved understanding of the ISO 9000 standards and TQM as well as their interdependencies that could serve as the basis for improved awareness on quality and QM in the Nigerian context.

Mirza Munir Ahmed, et. al., discuss hazards related to petrol fuel stations during operation and maintenance using a one year data collected from PFS located in different areas of Pakistan. During one year duration 1203 non-compliances were recorded. These non-compliances were categorized into 8 main elements and termed as Hazard Contributing Factors (HCFs) and highlighted the variation of HCFs in different seasons of the year. The result of study helps Health Safety and Environment (HSE) professionals to highlight non-compliances in different seasons of the year and take remedial and preventive actions to make PFS safer.

Editorial Committee

EFFECTS OF SPIRAL DIAMETER ON THE BOND STRESS-SLIP RELATIONSHIP IN GROUTED SLEEVE CONNECTOR

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Abstract
This paper presents the results of experimental tests on splice connectors joining two main steel bars. The objective was to investigate bond strength, slip and failure modes of the connected steel bars confined by the grouted sleeve connectors. A total of 21 grouted splice connectors were tested until failure under increasing axial load. Each sleeve connector consisted of steel pipe, steel spiral with vertical bars and cement grout. The key parameter was the diameter of the spiral reinforcement which confined the splicing of two steel reinforcement bars. The effects of spiral diameter of 35, 45, 55, 65, 75 and 85 mm on the bond strength and slip were critically investigated. The test results indicate that specimens with smaller spiral reinforcement accompanied by four shear keys provide greater bond strength. The improvement in bond strength is due to the confinement provided by the spiral reinforcement which eventually increases the axial tension capacity of the sleeve connector.

Keywords: *Grouted Sleeve Connector, Bond Strength, Slip, Confinement, Precast Concrete Connection*

INTRODUCTION

A mechanical splice, also known as coupler or sleeve connector, is widely used to splice two discontinuous steel reinforcement bars. Research into the development of mechanical splices used to join steel reinforcement bars has been ongoing since the late 1960's, including grouted splices invented by Alfred A. Yee (1968), Einea et al., (1995), Kim (2000), Ling (2006, 2008), Jansson (2008), Coogler et al., (2008) and Ahmad Baharuddin et al., (2010). Commercialization has spawned a variety of mechanical couplers (Albrigo et al., 1994, 1995). As most of these couplers have been the invention of private individuals, technical details have been difficult to obtain, as this information is viewed as private and confidential. An exception has been some recently published basic feasibility evaluation reports by Tokyo Steel Corp (1994), Jansson (2008) and Coogler et al., (2008).

The success of a grouted splice connector mainly relies on the ability of the connector to transfer load within the two discontinuous bars. Stress transfer between a reinforcing bar and adjacent grout requires good bond between the steel bar and the grout. It is now generally accepted that the bonding mechanism consists of three separate components: (i) adhesion between the grout and the bar, (ii) friction due to shrinkage and other effects, and (iii) mechanical interlock. In the case of deformed bars, the bond is achieved primarily through mechanical interlock with (i) and (ii) being secondary effects. In addition, shearing at the bar grout interface, as well as longitudinal splitting, are factors that contribute to failures.

Significant improvement in the anchor bond, which has led to reduction in the required embedment length of the connected steel bars has been attributed to a governing factor known as confinement (Robins and Standish, 1984, Einea et al., 1996, Moosavi et al., 2005). Various methods such as the use of transverse reinforcements surrounding the anchor bar zone (Soroushian et al., 1991), spirals (Lim, 2010, and Lee, 2009), aluminum tubes (Loo, 2009, and Ling et al., 2008), cylindrical pipes (Einea et al., 1995; Loh ,2008; Ling JH et al., 2009), square hollow sections (Ling et al., 2009) and fiber reinforced polymer (FRP) (Tibbetts et al., 2009) have been used to gauge the effects of confinement. Controlling the spread of the splitting cracks in the grout, either by bridging or by the resistance provided by the expansion materials surrounding the steel bars has required the application of these techniques.

This paper evaluates the behaviour of bond strength and bar slip of grouted splice connectors with respect to different spiral diameters. The characteristics and properties of spiral can be applied in Industrial Building System (IBS) to optimise the mechanical splice sleeve connector. As a result, it could be introduced comprehensively as an alternative to conventional lapping reinforcement bars.

EXPERIMENTAL PROGRAM

Test Specimens

The test specimens are basically grouted sleeve connectors used for joining two main steel bars. The component of each sleeve connector was mild steel pipe having a thickness of 4 mm and a length of 160 mm. Four steel bars as shear keys were welded onto the inner surface of the steel pipe. The properties of the shear keys were defined by 50 mm in length and Y10 high tensile bar. A main steel bar of Y16 was placed at both ends of the sleeve connector. The splice sleeve was then filled by non-shrink grout.

Series 1 consisted of control specimens S1, S2 and S3. Specimens S1 was prepared without any spiral or shear key. Specimen 2 was designed with shear keys only, and Specimen 3 was with shear keys and steel spiral. The details of these specimens are shown in Figure 1.

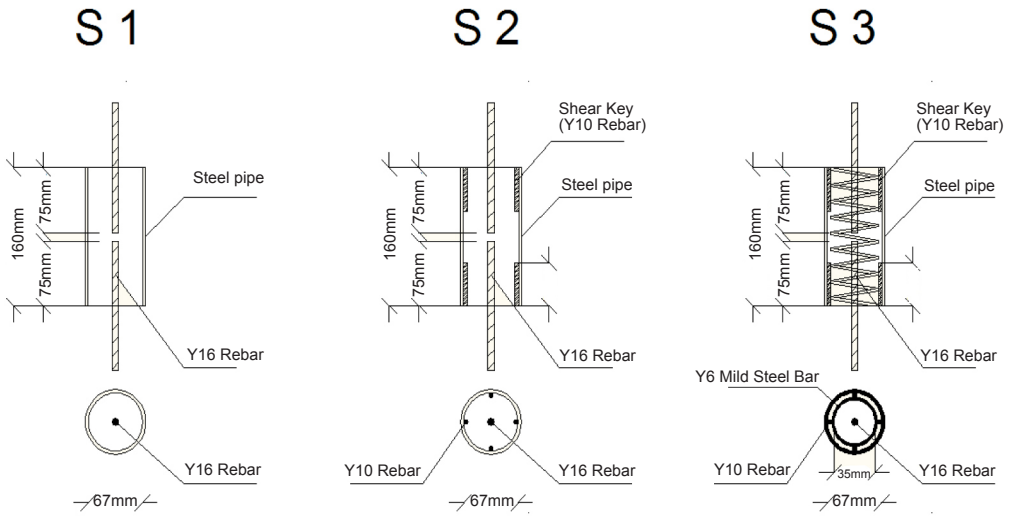


Figure 1. Detailing of the Control Specimens

Series 2, 3 and 4 are variation of S3 with different values of pitch distance and spiral diameter. Figure 2 and Table 1 show the details of these series and the corresponding parameters considered in the study.

Furthermore, as seen in Table 1, all the specimens are denoted in three groups namely P15, P25 and P35 with their spiral pitch distances of 15mm, 25mm and 35mm respectively. Since, the main objective of this research was to evaluate the effect of spiral diameter on the bond stress-slip relationship, then each group had six different spiral diameters which were 35mm, 45mm, 55mm, 65mm, 75mm and 85mm.

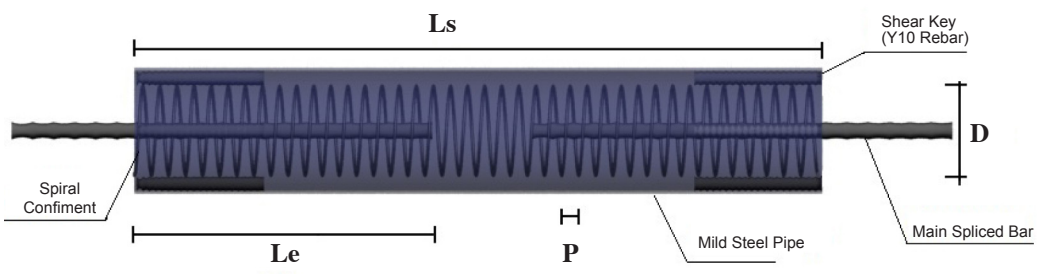


Figure 2. Details of all Specimens Comprising Main Spliced Bars, Mild steel pipe, Spiral reinforcement and Shear Keys

Material properties

Non-shrink grout was used as the infill material which had considerable influence on the performance of the connectors especially when seen from the aspect of bonding between reinforcement and grout. It was prepared with a mixing ratio of 25 kg of grout in 4 litres of water which was expected to have a compressive strength of 40MPa at 7 days after casting.

The main steel reinforcement used as the spliced bars was high yield steel of 16 mm diameter with bar rib pattern of deformed Type 2 and with an embedment length of 75mm. This embedded length was chosen to be short enough to provide uniform slip and uniform stress distribution and long enough to decrease the scatter of test resolution.

Mild steel pipe in grade 250MPa, 4mm thick and 160mm long was used as the main component of the splice. Then, R6 spiral reinforcement was welded to 4Y10 steel bars that act as shear keys. Subsequently, the shear keys provided additional shear resistance and contribute to mechanical interlocking effect to the contact surface between grout and spliced bars. It also distributed stress to larger areas.

Direct Pull out Test

All specimens were tested under increasing axial tensile load with a hydraulic activator operating at the rate of 0.5kN/s.

As shown in Figure 3, all spliced connectors were instrumented with a Linear Variable Differential Transformer (LVDT) to monitor the slip value. In addition, strain gauges were installed on the surface of the spliced bar prior to testing. A computer aided automatic data acquisition system was used to monitor the load, slip as well as strain in the reinforcement bars at every 2kN of incremental applied load.

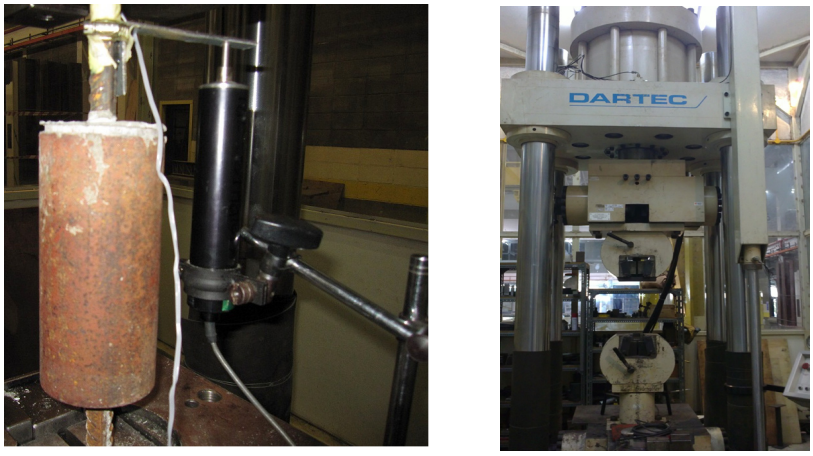


Figure 3. Use of LVDT to Monitor the Slip of the Spliced Bar

Table 1. Dimension of all Series

Series	Specimen	Pitch distance P(mm)	Spiral diameter D(mm)	Sleeve length L_s(mm)	Embedded length L_e(mm)
Series 1	S1	-	-	160	75
	S2	-	-	160	75
	S3	15	35	160	75
Series 2 (P15)	P15D35	15	35	160	75
	P15D45	15	45	160	75
	P15D55	15	55	160	75
	P15D65	15	65	160	75
	P15D75	15	75	160	75
	P15D85	15	85	160	75
Series 3 (P25)	P25D35	25	35	160	75
	P25D45	25	45	160	75
	P25D55	25	55	160	75
	P25D65	25	65	160	75
	P25D75	25	75	160	75
	P25D85	25	85	160	75
Series 4 (P35)	P35D35	35	35	160	75
	P35D45	35	45	160	75
	P35D55	35	55	160	75
	P35D65	35	65	160	75
	P35D75	35	75	160	75
	P35D85	35	85	160	75

RESULTS AND DISCUSSION

The experimental results of ultimate load, bond strength, and slip for each specimen of each group are shown in Table 2.

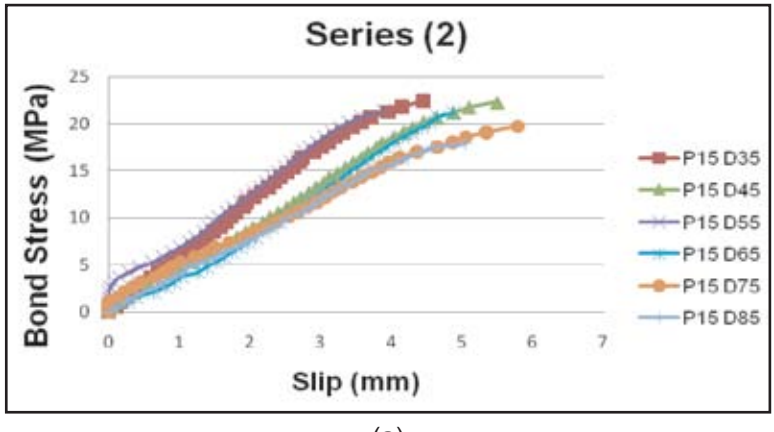
Assuming that the bond stress distribution along the embedded length in the grout is uniform, then the bond strength, τ , at any stage during loading is the ultimate applied pull-out load on the rebar, N, divided by the nominal surface area of the embedment length, L_e, of the rebar. For a circular rebar diameter, d, the bond strength is given by Equation 1.

$$\tau = \frac{N}{\pi.d.L_e} \qquad (1)$$

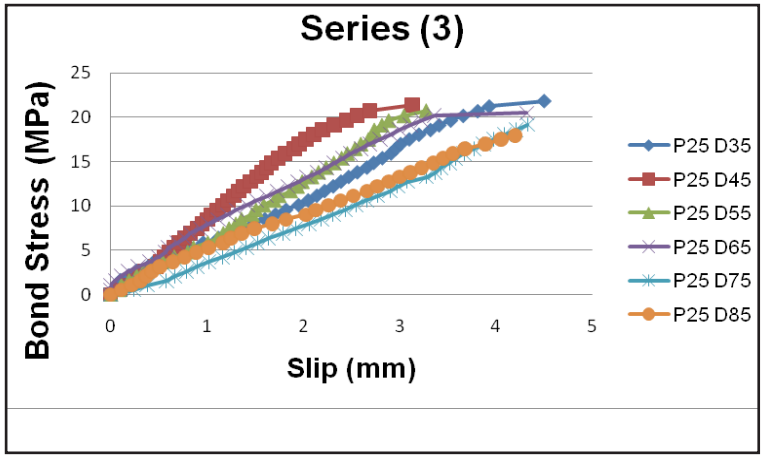
Where τ is the bond strength in MPa; N is the ultimate applied pull-out load in kN; d is the diameter of the rebar in mm; and L_e is the embedded length in mm.

The test results from Table 2 indicate that by having a smaller spiral diameter leads to higher bond strength and subsequently higher ultimate load. For instance, specimens P15D35, P25D35 and P35D35 which were belonged to the smallest spiral with 35 mm diameter had the highest bond strength in each series, also see Figure 4.

There are two factors which help to explain why a decrease in spiral diameter leads to an increase in the confinement effect of the specimens: (a) the ability of the grout to resist splitting expansion due to an optimum layer of grout surrounding the spliced bars (b) the propagation of the splitting cracks is controlled by the confinement, thus preventing the degradation of bond performance, see Figure 5. This shows that the confinement provided by the spiral is sensitive and effective in controlling the splitting expansion of grout (Ling JH 2011).



(a)



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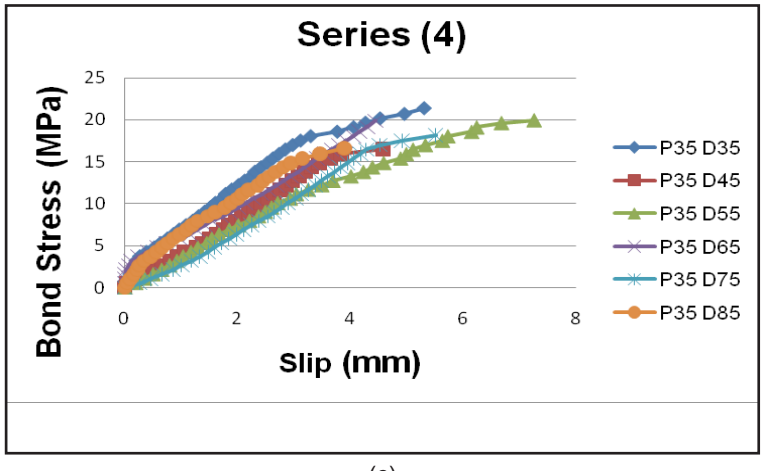


(c)

Figure 4. Bond Stress-Slip Relationship for (a) Series 2, (b) Series 3, (c) Series 4

Table 2. Summary of Performance for all Series

Series	Specimen	Ultimate Load, N (kN)	Bond Strength, τ (MPa)	Slip, s (mm)
Series 1 (Control Specimen)	S1	25.19	6.68	1.6
	S2	78.19	20.7	5.75
	S3	84.25	22.34	4.70

Series 2 (P15)	P15D35	84.63	22.45	4.45
	P15D45	84.03	22.29	5.5
	P15D55	80.56	21.36	3.89
	P15D65	79.81	21.01	4.88
	P15D75	74.35	19.7	5.79
	P15D85	67.44	17.89	5.05
Series 3 (P25)	P25D35	82.31	21.83	4.5
	P25D45	80.5	21.35	3.13
	P25D55	78.25	20.75	3.28
	P25D65	77.14	20.4	4.32
	P25D75	72.25	19.16	4.33
	P25D85	65.38	17.91	4.5
Series 4 (P35)	P35D35	80.56	21.37	5.3
	P35D45	62.5	16.51	4.58
	P35D55	75.23	19.55	7.26
	P35D65	74.94	19.82	4.45
	P35D75	68.5	18.17	5.51
	P35D85	62.29	16.62	3.89

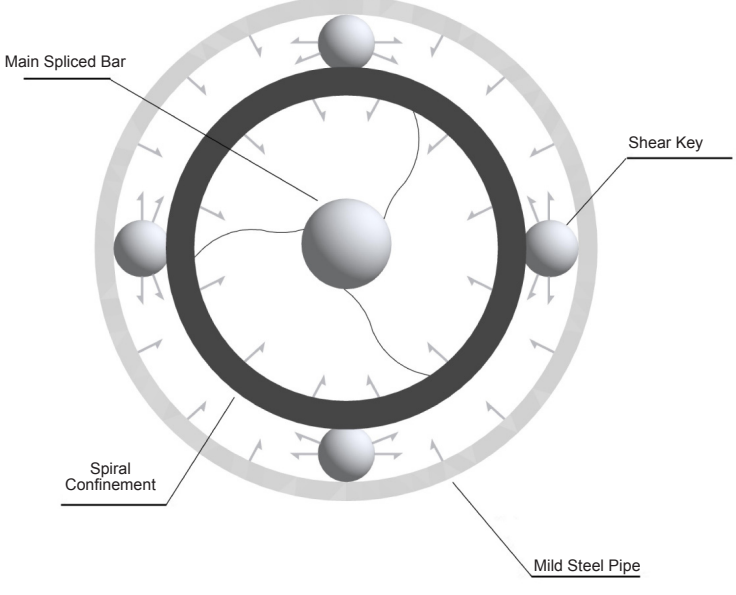


Figure 5. Propagation of Radial Cracks as Controlled by the Spiral Confinement

Behaviour of Grouted Splice

For the first control specimens, S1, force in one bar was transferred by bond into the grout, from the grout to the sleeve, and by the same way to the other bar. Because the sleeve was smooth and no shear keys were welded inside this type of connector, the bond between the inside surface and the grout was only due to the chemical bond, resulting in little friction between them. As a consequence, the compressive stress was significant at the interface between the grout and pipe. Thus, this type of the mechanical interlock could not withstand the tensile stress, and it slipped from inside the pipe. Eventually the splice sleeve connector lost its performance and the corresponding failure mode was grout slippage.

For S2, the second control specimen, four steel bars as shear keys were presented into the inner surface of the steel pipe to provide a better interlocking mechanism, to enhance the bond property between grout and the sleeve and to prevent the grout from slipping. The ultimate bond stress of this specimen is 20.7MPa which is three times that of S1 with a bond stress of 6.68MPa. This means that four shear keys significantly affect the performance of the connector, and can also change the pattern of failure to bar slippage.

The bond strength of the third control specimen, S3, is not much different from specimen S2. The bond strength of this specimen is 22.34MPa which is close to S2 with an ultimate bond stress of 20.7MPa.

The results show that slip had reduced from 5.75mm for the second specimen without spiral to 4.70mm for the third specimen with spiral confinement. This shows that, the spiral reinforcement has the potential to control slip and prevent sudden deterioration of the connector. Figure 6 shows the failure modes of specimens S1, S2, S3.

(a) (b) (c)

Figure 6. Failure Modes of Specimens (a) S1, (b) S2, (c) S3

The purpose of this research was to investigate the response of bond strength with respect to different spiral diameters. Embedded length of 75mm was chosen and therefore bar pull out failure was expected. As shown in Table 2, the mechanism of bond failure tended to be bar pull out. Increasing tensile force was applied at both ends of the splice sleeve connector, and as a result the spliced reinforcement bars inclined to slip along with pulling load. The mechanical interlock between spiral confinement and grout caused the bonding property to configure between surrounding reinforcement bars and grout. Incremental load was applied until radial cracks developed at both ends of the specimens. As the incremental load increased further, the grout keys between the lugs crushed and shearing occurred. When the pull out force exceeded the bonding capacity, the reinforcement bars slipped out of the sleeve. Figures 8 to 13 show the observed failure modes for all the specimens.

On the other hand, the data from the strain gauges installed on the spliced bar extruding from the grouted sleeve prove that the specimens reached the failure point while the reinforcement bar was still in its elastic area, see Figure 7. The embedment length was not long enough to allow for an adequate bond between the rebar and infill material, so bar slippage occurred before it reached its yield stress. The graphs for the other series are the same and all of them failed within the elastic area.

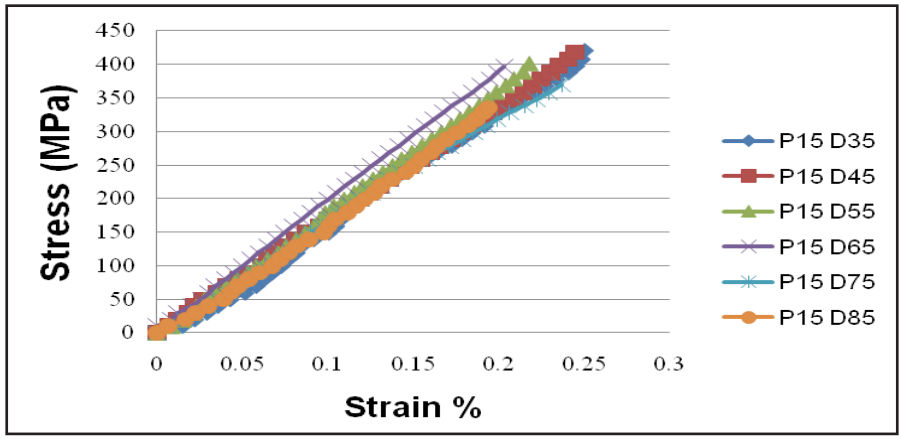


Figure 7. Comparison of Stress versus Strain for Series 2

Figure 8. Bar Slippage from Left to Right: P15 D35, P25 D35 and P35 D35

Figure 9. Bar Slippage from Left to Right: P15 D45, P25 D45 and P35 D45

Figure 10. Bar Slippage from Left to Right: P15 D55, P25 D55 and P35 D55

Figure 11. Bar Slippage from Left to Right: P15 D65, P25 D65 and P35 D65

Figure 12. Bar Slippage from Left to Right: P15 D75, P25 D75 and P35 D75

Figure 13. Bar Slippage from Left to Right: P15 D85, P25 D85 and P35 D85

Analysis of Results

To evaluate the bond performance of the grouted splice connector, Equation 2 is adopted. According to the British Standard 8110 Part1, clause 3.12.8.4 (1997), the design anchorage bond stress should not exeeced the design ultimate anchorage value given in Equation 2.

$f_{bu}=\beta\sqrt{f_{cu}}$ (2)

where :

β = coefficient dependent on bar type, obtained from Table 3.26 BS8110

f_{cu} = the infill compressive strength

The value of β is taken as 0.5 as obtained from Table 3.26 for type 2 deformed bar in tension and the grout grade is 60.01N/mm^2. In this experimental test, however, the values of bond strength are in the range of 16.51N/mm^2 to 22.45N/mm^2 which are higher than the design ultimate bond stress of 3.9N/mm^2 pointed in BS 8110 Part1(1997). The large increase in the bond stress values is due to the effect of confinement provided by the steel pipe, spiral and four shear keys in the specimens.

This confinement mechanism was demonstrated theoretically by Untrauer and Henry (1965) as given in Equation 3. They found that the ultimate bond stress is a function of lateral confining pressure.

$U= (18+ 0.45\sqrt{f_n})\ f_{c'}$ (3)

Where,

U= bond strength of grout

f_n= lateral confining pressure

fc'= grout compressive strength

$$f_n = \frac{2\ \varepsilon_s.t.E}{d_i} \quad (4)$$

Where,

ε_s = tangential strain in the pipe

t = thickness of the pipe wall

E = modulus of elasticity of the pipe

d_i = internal diameter of the pipe

From Equation 4, it can be seen that the lateral confining pressure is a function of inner diameter of the steel pipe. In this study, the presence of spiral reinforcement inside the steel pipe has reduced the internal diameter of the pipe, d_i. This effect increases the confining pressure, f_n and subsequently the ultimate bond strength. This phenomenon is evident from the plot of bond stress versus diameter of spiral shown in Figure 14. It can be seen that reducing the diameter of spirals, would increase the bond strength of the connector.

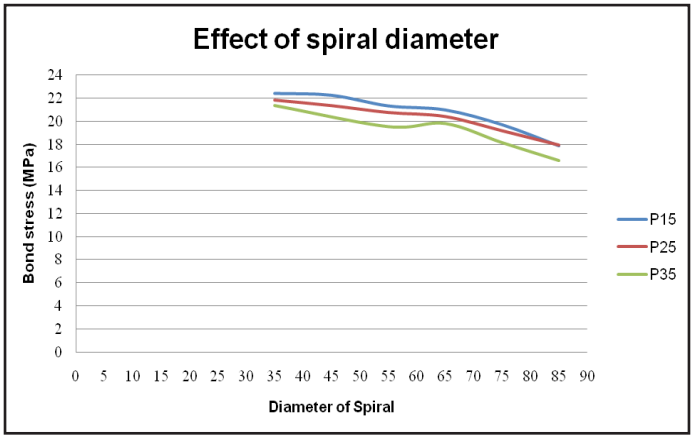


Figure 14. Effect of spiral diameter to the bond strength for series 2, 3 and 4

Analytical Model of the Bond–slip Constitutive Relationship

Eligehausen, et al. 1983 proposed the well-known bond-slip analytical relationship for deformed steel bars, known as the BPE model. The relationship is given in Equation 5 and the corresponding response is shown Figure 15. The first segment AB of the curve refers to the case where the reinforcement ribs are still in place in the grout matrix, and the curve close to point B represents the local crushing and micro-cracking in the grout. The horizontal part, BC takes place only for confined concrete, characterized by the advanced crushing and shearing of the concrete between the ribs. The descending level, CD is the reduction of bond resistance due to the occurrence of splitting cracks.

$$\tau/\tau_1 = [s/s_1]^{\alpha} \qquad (5)$$

Where:

τ_1 = maximum bond strength

s_1 = corresponding slip at τ_1

α=a curve-fitting parameter

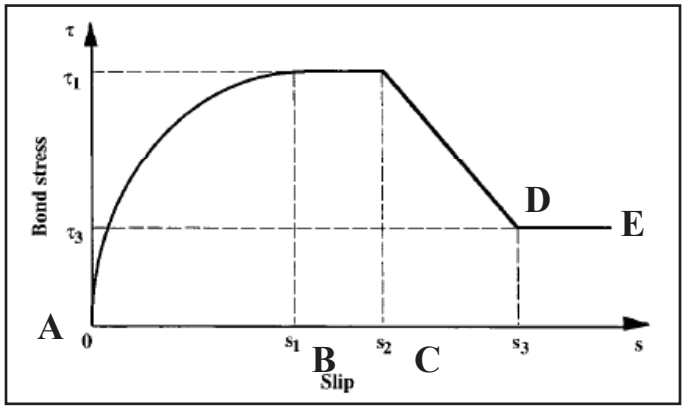


Figure 15. BPE model

In this paper, the BPE model in Equation 5 is adopted and modified to predict the bond-slip relationship of the splice connector with spiral reinforcement. This involved the use of Equation 6 and the modification of curve fitting factor, α given in Equation 7. Based on the proposed, α and data obtained from these experimental tests, the BPE model of the splice connectors are plotted in Figure 16. Each curve shown in the figure expresses the ascending curve of bond-slip where the slip, $s < s_2$. As can be seen from Figure 16, the proposed, α has successfully fit the responses of bond-slip of the tested splice connectors, in-line with the first segment AB of BPE model.

Using Equations 6 and 7, one can predict bond strength, τ and slip, s with respect to different pitch distance, P and spiral diameter, D of the spiral reinforcement.

$$\tau/\tau_m = [s/s_m]^{\alpha} \qquad (6)$$

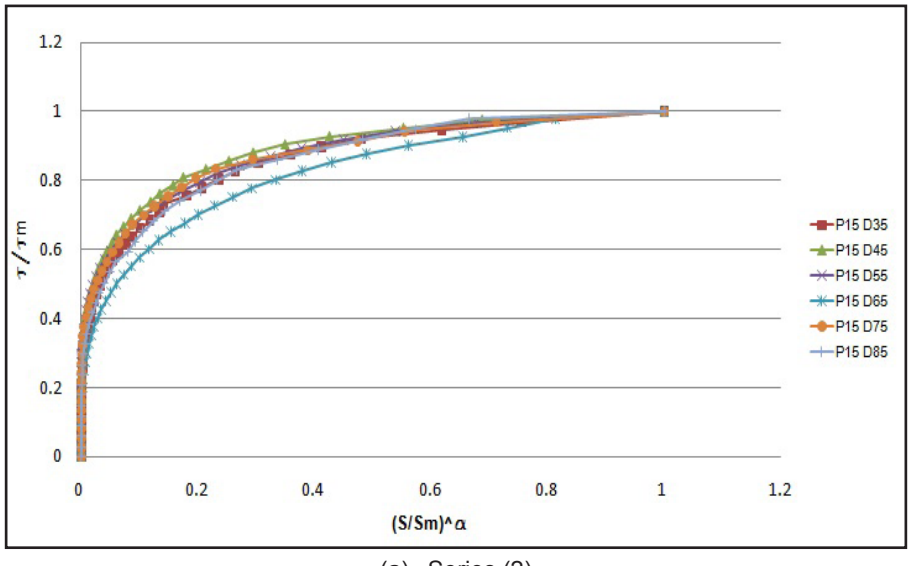
in which:

$$\alpha = P/D^{0.35} + c \qquad (7)$$

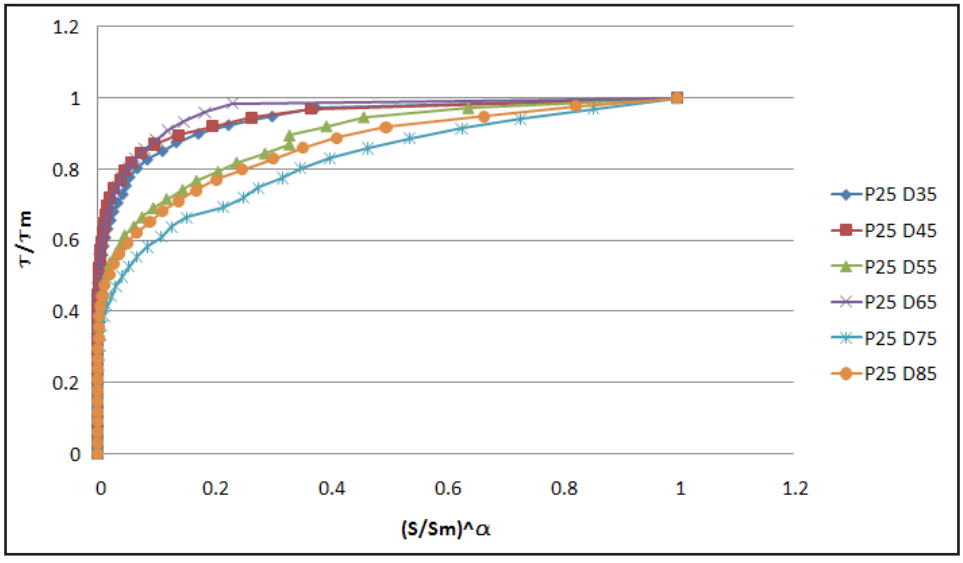
and,

c =1 for pitch distance of 15mm

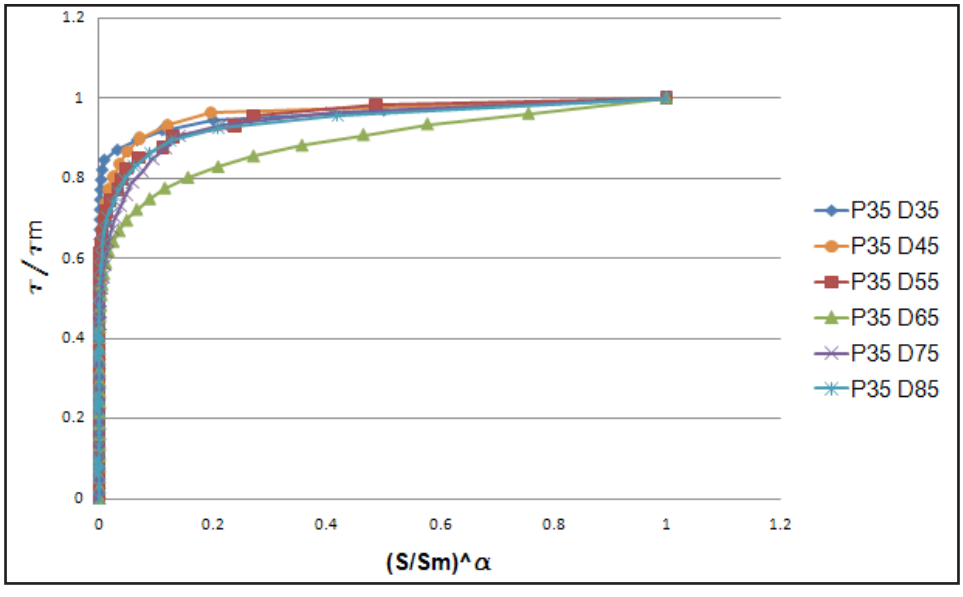
c = 0 for other pitch distances



(a) Series (2)



(b) Series (3)



(c) Series (4)

Figure 16. Modelled behaviour of grouted splice subjected to tensile load

CONCLUSION

In this paper, the effect of spiral confinement on the bond stress-slip has been studied. Based on the results of the experimental and analytical studies, the following conclusions can be drawn:

i. Providing shear keys led to an increase in the ultimate bond stress by three times. This shows the efficiency of the shear keys for improving the performance of the connector. In addition, by attaching spirals on the shear keys, it is possible to control the movement and the range of slip. Thus, by account of interaction between slip and ultimate bond stress, higher performance of connectors can be achieved.

ii. The configuration of spiral confinement affects the contribution of the loading capacity of the splice sleeve connector. The use of smaller spiral diameter results in higher bond strength because of better confinement provided by the enhanced mechanical interlocking properties of the specimen.

iii. A smaller spiral diameter accompanied by four shear keys gives the best performance of the splice sleeve connector and can generally enhance the bond strength in any other connectors also.

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EFFECTS OF GEOMETRICALLY CUBICAL SHAPE AGGREGATES ON THE RESILIENT MODULUS, CREEP STIFFNESS AND RESISTANCE TO RUTTING OF ASPHALTIC CONCRETE

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Abstract
In Hot Mix Asphalt (HMA), mineral aggregate mix encompasses approximately 85% by volume. Therefore, aggregate properties have significant effect on the performance of asphaltic concretes. This study concentrates on the effects of incorporating various percentages of Geometrically Cubical Shaped (GCS) aggregate in the asphaltic concrete on volumetric properties, resilient modulus, creep stiffness and resistance to rutting. Two different aggregate blends of normal shaped aggregate and GCS aggregate were used to prepare five different percentages of GCS aggregate, designated as Mix M0, M25, M50, M75 and M100.Mix heights were recorded during compaction to evaluate workability. The engineering properties of the mixes were determined from the resilient modulus, creep stiffness (dynamic creep) and resistance to rutting (immersion wheel tracking) tests. Mix M100, consisting of 100% GCS aggregate, performed best in all tests. One-way ANOVA and Duncan's Post Hoc statistical analysis test results showed that incorporation of GCS aggregate has significant effects on workability index, resilient modulus, creep stiffness and resistance to rutting of asphalt specimens.

Keywords: *Geometrically Cubical Aggregate; Rutting; Creep Stiffness; Resilient Modulus; Wheel Tracking; Dynamic Creep; Workability Index.*

INTRODUCTION

The increasing demand for aggregates from the road construction industry causes the deterioration of the environment and depletion of natural resources. In order to reduce the environmental impact, researchers have been searching for enhanced aggregate properties that can improve asphaltic concrete durability and subsequently conserve usage of depleting raw materials. In Hot Mix Asphalt (HMA), mineral aggregate encompasses approximately 85% by volume (Ahlrich, 2007). Therefore, aggregate properties have significant effect on the performance of asphalt mixes.

Cubical aggregate, rather than flat, thin, or elongated particles are more suitable for use in HMA. Angular-shaped particles exhibit greater interlock and internal friction in compacted mixtures, and, hence, result in greater mechanical stability than rounded particles (Roberts et al. 1996). Better interlocking due to angular aggregates consequently increase rut resistance (Kandhal and Mallick 2001; Brown and Bassett 1990). Bari and Witczak (2006) mentioned that two mixes with different aggregate shape parameters but the same aggregate gradation and volumetric properties might result in different dynamic modulus. Johnson et al. (2007)

have investigated the effect of aggregate shape parameters on the performance of HMA. Performance testing, namely dynamic modulus and rut testing was conducted on four different types of asphalt mixes by varying the quantity of fine aggregate angularity. It was found that rut resistance and dynamic modulus are strongly related to fine aggregate angularity. A change in the aggregate shape parameters cans strongly influence pavement performance.

Flat and elongated aggregate particles are undesirable for road construction. Several design procedures incorporate specifications that set limiting values of flat and elongated aggregate in the mix. High percentages of flat and elongated aggregate particle in a mix are undesirable as they tend to break down under roller compaction and expose the uncoated aggregate surfaces. Flat and elongated particles causes poor mix stability, artificially increased asphalt contents, increased breakdown of aggregate particles during compaction and shorter pavement fatigue life. The main aim of this study is to evaluate the effects of incorporating various percentages of GCS aggregates on the properties of asphaltic concrete prepared according to the Malaysian Public Works Department (JKR) specifications (JKR, 2008). A graphical comparison could provide greater insight into the potential benefits of incorporating GCS aggregate particles into the asphaltic concrete mix.

MATERIALS AND MIX GRADATION

A conventional asphalt binder penetration grade 80/100 supplied by PETRONAS, was used to prepare the samples. The manufactured aggregate was crushed by using Rock on Rock (RoR) Vertical Shaft Impactor Crusher (Barmac B3000 Duopactor). Crushing reduced the rock dimensions to the desired sizes to make them suitable for use in asphaltic concrete. There were four basic ways to obtain the shaped aggregate namely; via impact, cleavage, attrition and abrasion. The maximum feed material size to the crusher was 20mm.The material was rapidly accelerated by the centrifugal force of the rotor action and was compressed against the rock lining which was formed in the crushing chamber. However, the effects of operating variables, namely the rotor speed, feed rate and cascade ratio significantly affects the resultant size, shape and surface texture of the re-crushed aggregate (Metso, 2011).

The aggregate test results for both aggregate shapes are summarised in Table 1. The mix type used for the experiment was AC14, based on the JKR specifications (JKR, 2008). The median gradation served as the target gradation. The mixes were designated as M0, M25, M50, M75 and M100 which represents mixes that incorporate 0%, 25%, 50%, 75% and 100% GCS aggregate proportions respectively. The resultant optimum binder contents used were 5.3%, 5.2%, 5.1%, 5.0%, 4.9% for M0, M25, M50, M75 and M100, respectively. The asphalt content for mix incorporating GCS aggregates was found to be lower than normal aggregate mix due to its higher surface area of normal aggregates compared to GCS aggregate.

Table 1. Aggregate properties

Property	Type of Aggregate Shape	
	GCS	Normal
Flakiness Index (%)	6.0	21.3
Elongation Index (%)	10.1	23.7
Aggregate Crushing Value, ACV (%)	16.2	20.4
Aggregate Impact Value, AIV (%)	17.4	20.5

LABORATORY TEST

The mix air voids was determined based on the bulk specific gravity of compacted mix (G_{mb}) and the theoretical maximum density of the loose mix (G_{mm}) according to ASTM, (2000). The concept of workability index developed by Zoorob and Cabrera (1991) was used to evaluate mix workability. A high workability index indicates a more workable mix or mix that is easier to compact. The linear relationship between air voids and number of gyrations can be expressed by Equation 1.

$$Y = A - Bx \qquad \text{Equation (1)}$$

Where Y is air voids (%), A, B are constants and x is the logarithmic number of gyrations ($\log_{10}$).

From Equation1, the constant A is obtained by extrapolating the straight line to intersect with the Y-axis at zero gyration. The workability index (WI) is defined by Equation 2.

$$WI = \frac{100}{A} \qquad \text{Equation (2)}$$

The resilient modulus test measured the stiffness of the samples at 25 °C and 40°C and carried out based on ASTM, (2005) procedures. The resilient modulus of elasticity was calculated from Equation 3.

$$M_R = \frac{P}{Ht}(0.27 + \mu) \qquad \text{Equation (3)}$$

Where M_R is the resilient modulus of elasticity (MPa), P is the repeated load (N), H is the instantaneous recoverable horizontal deformation (mm), t is the thickness of sample (mm) and μ is the Poisson's ratio.

The dynamic creep test was carried out according to EN (2005) procedures at 40°C. The parameter used for the test is shown in Table 2.The test was run at cyclic stress of 100kPa for 10000 cycles.

Table 2. Dynamic creep test parameters

Parameter	Values
Temperature	40°C
Loading function	Haversine
Cyclic stress (kPa)	100
Seating stress (kPa)	20
Load cycle width (ms)	100
Load cycle repeat time (ms)	1000
Preload stress (kPa)	20
Preload time (s)	60
Cycle count	10000

The samples prepared for the immersion wheel tracking test has 7±0.5% air voids and 150mm in diameter. The procedures for the immersion wheel tracking test were based on EN (2003). The sample was tested at 50°C and the number of cycles was set at 10000 cycles which was equal to 20000 passes of the wheel on the surface of the sample.

RESULTS AND DISCUSSION

Volumetric Properties

The JKR specifications stipulate air voids ranging from 3.0% to 5.0%. Low air voids is desirable to reduce ingress of moisture and air into the asphaltic concrete. High air voids leads to moisture sensitivity problems and hastens binder aging. All samples were compacted at 100 gyrations using the gyratory compactor with air voids 4±0.5%. The relationship between air voids and number of gyrations is shown in Figure 1. Mix workability index was calculated based on these relationships.

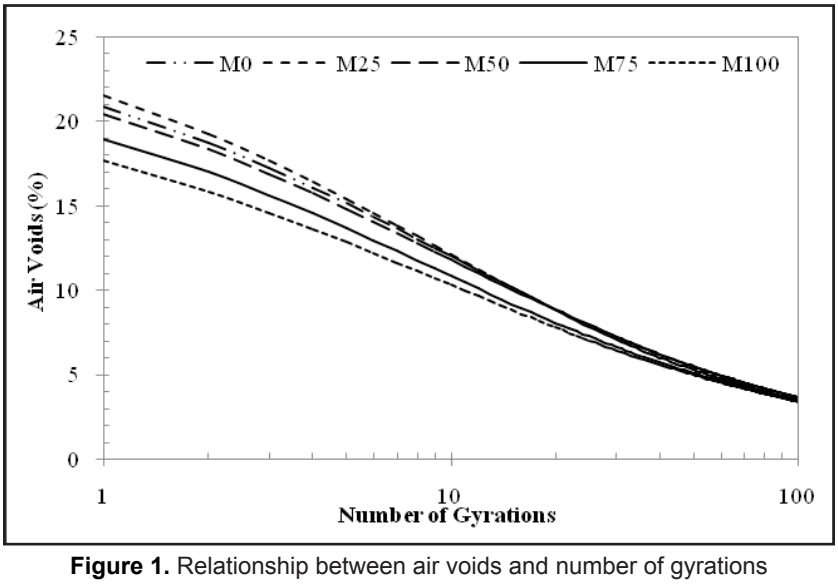

Figure 1. Relationship between air voids and number of gyrations

In general, the average workability index increases as the proportion of GCS aggregates increases (mix M0 to M100). Figure 2 shows the relationship between workability index and proportion of GCS aggregate in the asphaltic concrete. The statistical analysis shows that the P value is less than 0.05 as shown in Table 3. The results of Duncan's Post Hoc test analysis in Table 4 shows M75 and M100 has significant effect on the mix workability index.

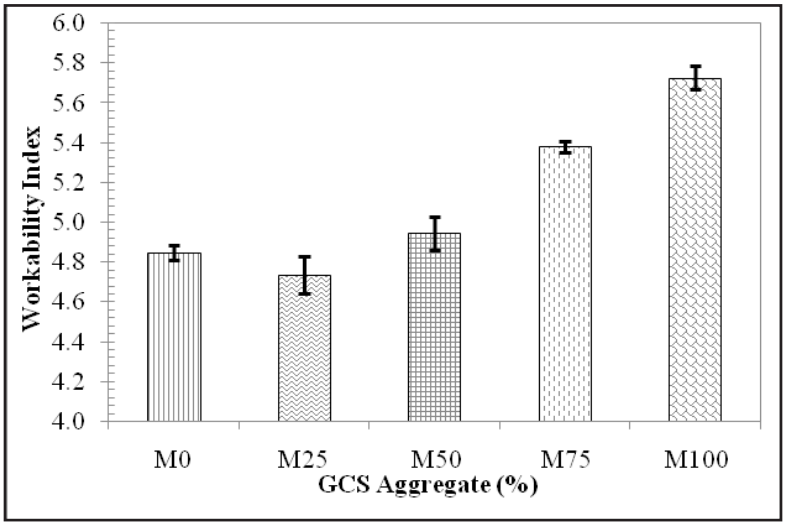

Figure 2. Relationship between workability index and the GCS aggregate

Table 3. One-way ANOVA results on workability index

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.390	4	.347	38.246	.001
Within Groups	.045	5	.009		
Total	1.435	9			

Table 4. Duncan's Post Hoc Test Analysis on Workability Index

Percentage	N	Subset for alpha = 0.05		
		1	2	3
25	2	4.7278		
0	2	4.8483		
50	2	4.9449		
75	2		5.3816	
100	2			5.7268
Sig.		.078	1.000	1.000

Effects of GCS Aggregate on Resilient Modulus

From Figure 3, the resilient modulus at 25°C for mix M0 and M100 equals 3670MPa and 4903MPa, respectively. Hence, the resilient modulus of mix incorporating 100% GCS aggregates is 33.6% higher compared to the resilient modulus of mix incorporating 100% normal shape aggregates (mix M0). Figure 4 shows the resilient modulus test results on mixes

tested at 40°C.The resilient modulus of mix M100 and M0 are 1179 MPa and 560 MPa, respectively, which represents a 110% increase. The positive effect of incorporating GCS aggregate is clearly evident from the increased resilient modulus for every 25% increase of GCS aggregate content in the asphalt mixes.

The resilient modulus increases as the percentage of GCS aggregate increases. For mixes prepared with normal shape aggregate, unstable interlocking between the aggregate causes them to move further and consolidate upon loading. This phenomenon is undesirable as it will lead to permanent deformation. When tested at 40°C, the asphalt mix stiffness reduces and consequently reduces the resilient modulus. Despite this reduction, the resilient modulus of mix M100 is 110% higher compared to the control mix M0.

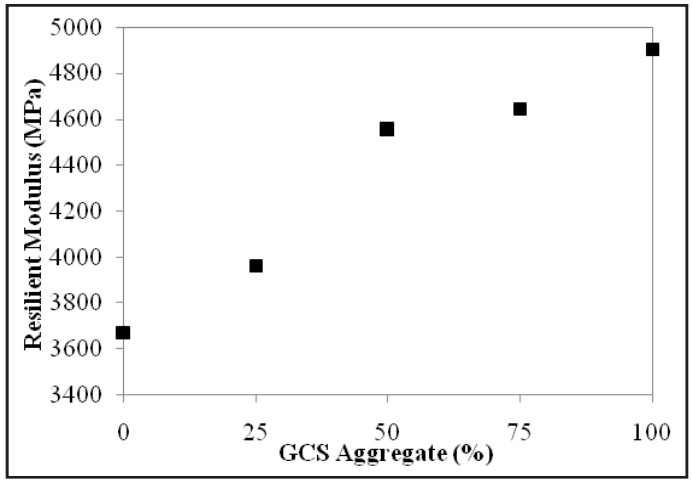

Figure 3. Relationship between resilient modulus at 25°C and proportion of GCS aggregate

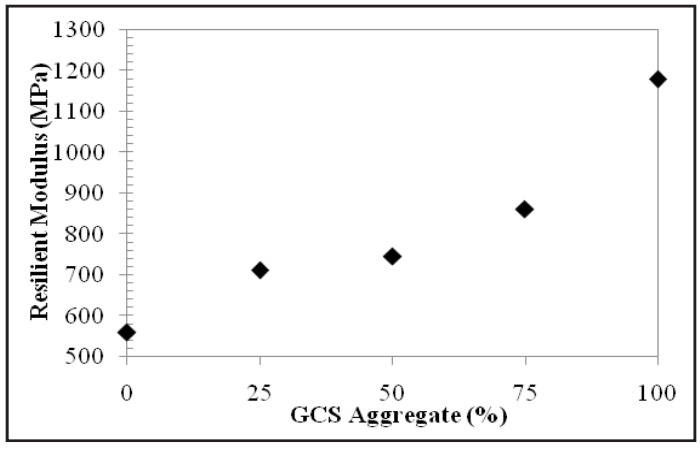

Figure 4. Relationship between resilient modulus at 40°C and proportion of GCS aggregate

The result of Two-way ANOVA test is summarised in Table 5. The P-values for temperature, percentage, and interaction between temperature and percentage factors are less than 0.05. Therefore, it indicates that there is an interaction effect between temperature and GCS percentage. An interaction plot between temperature and GCS percentage is shown in Figure 5. Since the interaction between temperature and GCS percentage is significant, therefore, the best resilient modulus will occur at 100% GCS aggregate and at 25°C.

Table 5. Univariate ANOVA results on resilient modulus

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Percentage (P)	2089171.300	4	522292.825	40.614	.000
Temperature (T)	62475822.612	1	62475822.612	4858.184	.000
P * T	432981.700	4	108245.425	8.417	.003
Error	128599.125	10	12859.913		
Total	1.981E8	20			
Corrected Total	65126574.737	19			

*P = Percentage; T = Temperature

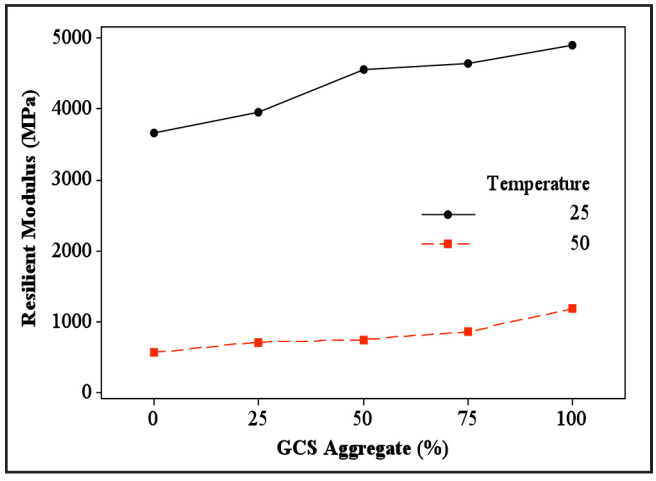

Figure 5. Interaction plot between temperature and proportion of GCS aggregate

Dynamic Creep

Effects of GCS Aggregate on Creep Modulus

The dynamic creep test results are presented in Figure 6. The cumulative strain of control mix M100 is the lowest among the five mixes tested.

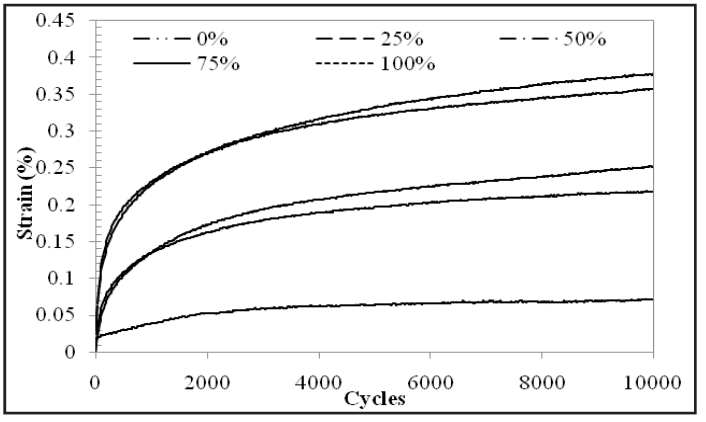

Figure 6. Relationship between strain and the effects of GCS aggregate percentage on asphalt concretes

The creep modulus is obtained by dividing the applied stress with cumulative axial strain of the sample. Higher creep modulus indicates higher mix resistance to permanent deformation. Figure 7 shows the result of creep modulus for mixes with different percentages of GCS aggregate. Mix M100 exhibits the highest creep modulus at 142.9 MPa, while mix M25 exhibits the lowest creep modulus equivalent to 26.5 MPa. The creep modulus of mix M100 is four times higher than mix M0.

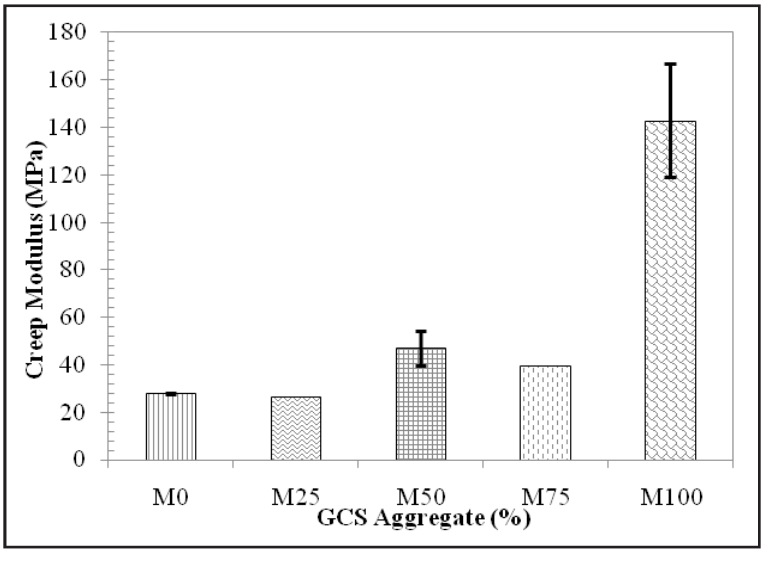

Figure 7. Relationship between creep modulus and proportion of GCS aggregate

Effects of GCS Aggregate on Creep Rate

During service, the short term creep rate takes place due to traffic over compaction, while the long term creep rate is caused by the reorientation of the aggregates in the mix. Figures 8 and 9, respectively show the short term and long term creep rates for mixes with different percentages of GCS aggregates.

The short term creep rate result is shown in Figure 8. Mixes M100 and M0 respectively register 0.00002% and 0.0003% creep rate per cycle. The corresponding values for long term creep rate are respectively 1.00E-06% and 7.00E-06% per cycle. The long term creep rate for mix M0 is 7 times higher compared to M100.

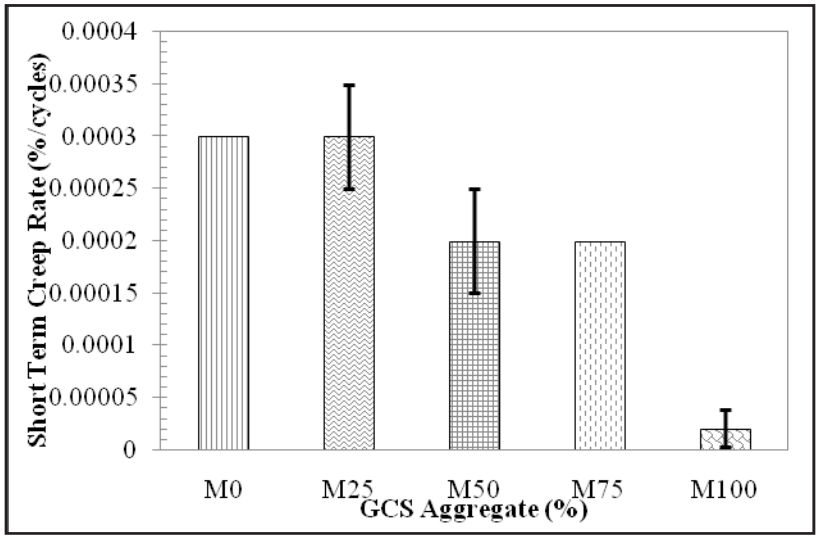

Figure 8. Relationship between short term creep rate and proportion of GCS aggregate

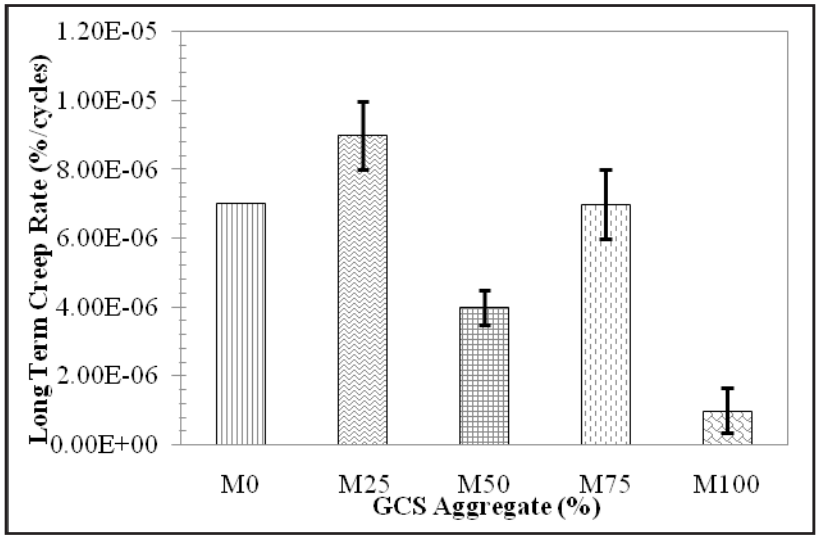

Figure 9. Relationship between long term creep rate and proportion of GCS aggregate

Resistance to Rutting

Effects of GCS Aggregate on Strain and Dynamic Stability

The cumulative strain obtained from the wheel tracking test is presented in Figure 10. Mixes containing 50% and higher GCS aggregate proportion exhibit lower cumulative strain compared to mix M0 and M25. Figure 11 shows the relationship between cumulative strain and number of cycles for all mixes tested.

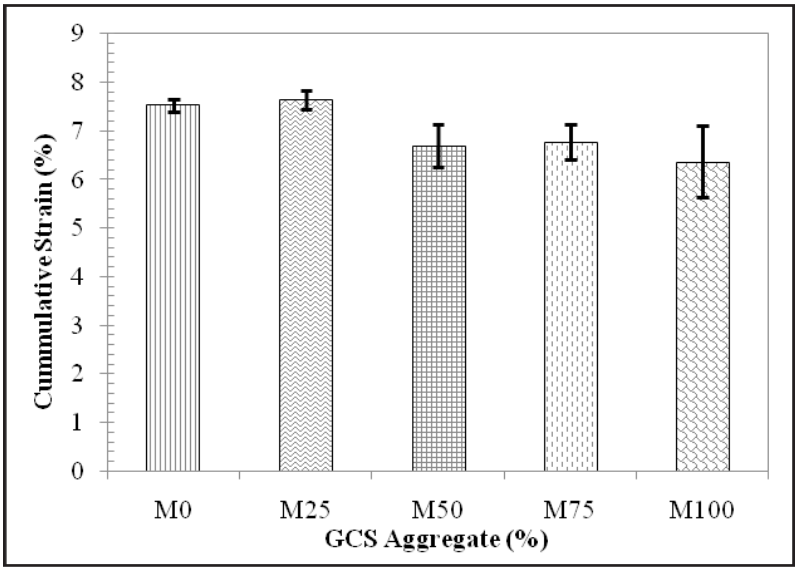

Figure 10. Relationship between cumulative strain and proportion of GCS aggregate

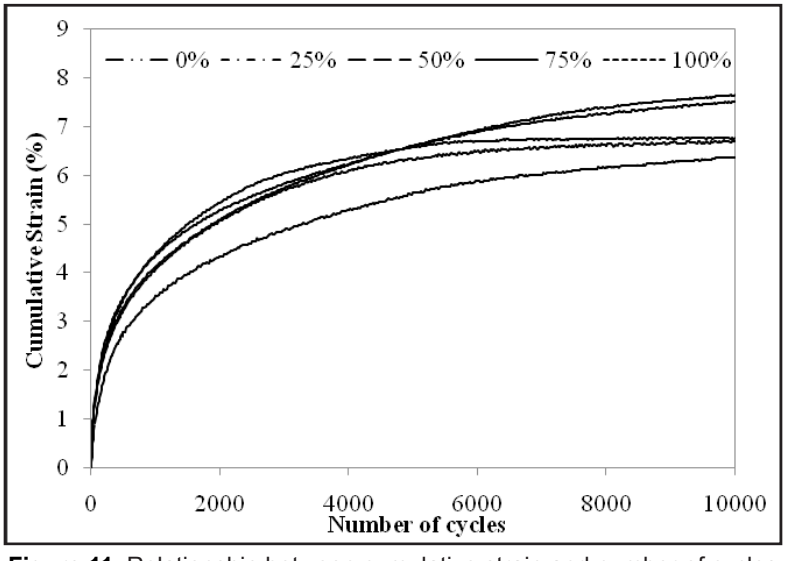

Figure 11. Relationship between cumulative strain and number of cycles

The mix Dynamic Stability (DS) is determined from the rut development curve. The DS is defined as the number of wheel passes to induce 1 mm of permanent deformation during the steady state. Figure 12 presents the effects of different percentages of GCS aggregate on the DS of mixes. The results show that mix M100 exhibits the highest DS of 3338 passes/mm indicating that mix M100 is the most resistant to permanent deformation. One-way ANOVA analysis tabulated in Table 6shows a P-value of more than 0.05. This indicates that the mean of dynamic stability is insignificantly different and therefore the percentages of GCS aggregate have an insignificant effect on mix dynamic stability.

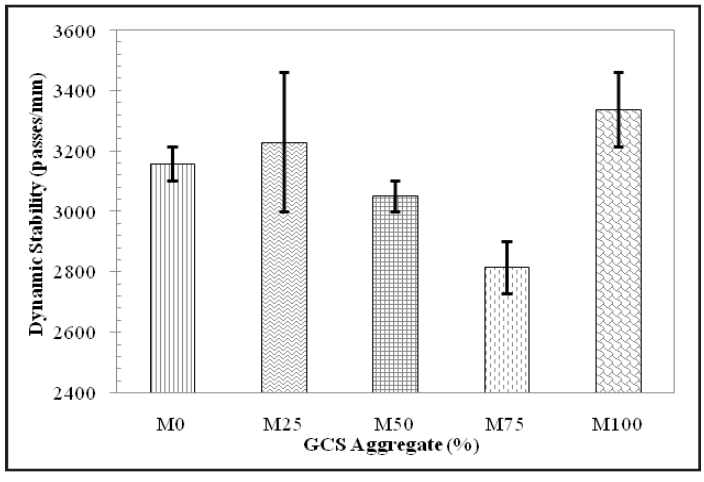

Figure 12. Relationship between dynamic stability and proportion of GCS aggregate

Table 6. One-way ANOVA results on dynamic stability

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	318074.600	4	79518.650	2.418	.180
Within Groups	164427.000	5	32885.400		
Total	482501.600	9			

Effects of GCS Aggregate on Wheel Tracking Rate

The Wheel Tracking Rate (WTR) is obtained from the slope of the rutting curve using statistical linear regression analysis with a coefficient of determination (R^2) above 95%. The short term rut rate is defined as the mean increase in rut depth determined over the final 15 minutes of the wheel tracking test which lasted for 45 minutes. Figure 13presents the relationship between short term rut rate and various percentages of GCS aggregate.M100 presented the least rut rate at 0.005% per cycle which is an 11% difference as compared to M0.

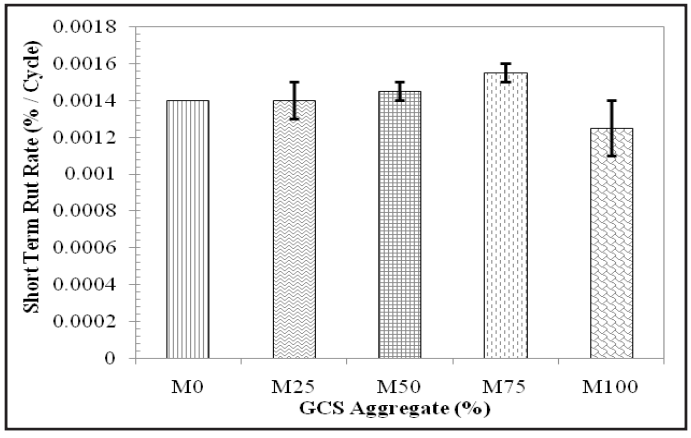

Figure 13. Relationship between short term rut rate and proportion of GCS aggregate

The long term rut rate is the rate of rutting which takes place during secondary compaction after the mix has stabilised. Figure 10 illustrates the rut development curves. The cumulative strain increases proportionally with number of cycles beyond 5000 cycles. The slope of the lines shown in Figure 14, obtained from a statistical linear regression analysis, is an expression of the long term rut rate. Mix M100 has a long term rut rate of 0.0001% per cycle. Both mix M0 and M25 exhibit long term rut rate equal to 0.0002% per cycle.

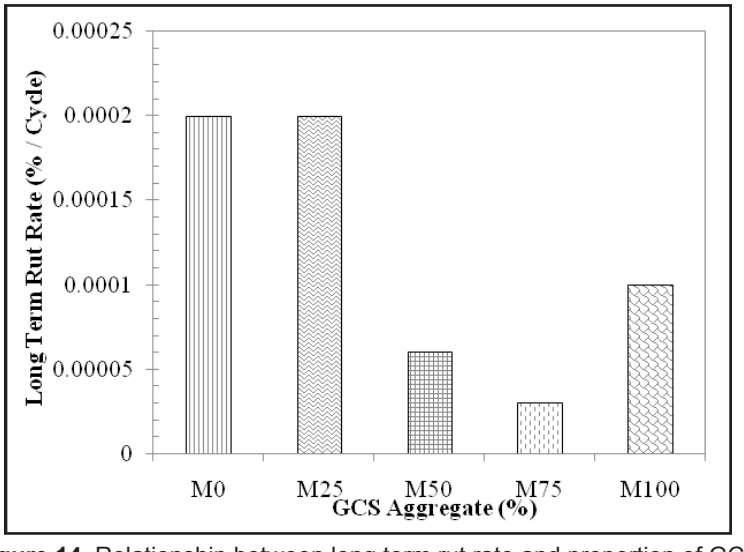

Figure 14. Relationship between long term rut rate and proportion of GCS aggregate

The One-way ANOVA analysis result is shown in Table 7. A P-value of more than 0.05 indicating that the proportion of GCS aggregate have an insignificant effect on short term rut rate of the mixes. However, in Table 8, the result of the One-way ANOVA analysis for long term rut rate shows a significant effect. Table 9 presents the Duncan's Post Hoc test analysis results. All of the mixes are grouped into two groups. Group 1 refer to mixes M50, M75 and M100 that incorporates higher percentage of GCS aggregate. On the other hand, Group 2 incorporates mixes M0 and M25. This directly implies that the proportions of GCS aggregate in Groups 1 and 2 have different effect from each other.

Table 7. One-way ANOVA results on short term rut rate

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	< .001	4	< .001	1.567	.314
Within Groups	< .001	5	< .001		
Total	< .001	9			

Table 8. One-way ANOVA results on long term rut rate

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	< .001	4	< .001	9.730	.014
Within Groups	< .001	5	< .001		
Total	< .001	9			

Table 9. Duncan's posthoc test analysis on long term rut rate

Percentage	N	Subset for alpha = 0.05	
		1	2
100	2	.000100	
75	2	.000065	
50	2	.000065	
25	2		.000200
0	2		.000200
Sig.		.325	1.000

CONCLUSIONS

The effects of five proportions of GCS aggregate on HMA are evaluated on asphaltic concrete. A higher percentage of GCS aggregate leads to lower air voids for a given number of gyrations. This helps to improve the performance of the asphaltic concretes by preventing the ingress of air and water. The workability index for mix M100 is 18% higher than mix M0. Furthermore, the optimum binder content required for mixes incorporating GCS aggregate is lower compared to mixes prepared with normal shape aggregate. Mixes tested at higher temperature (40 °C) exhibit lower resilient modulus values compared to mixes tested at lower temperature (20 °C). However, regardless of test temperature, incorporation of higher proportions of GCS aggregate results in higher resilient modulus. At 40°C test temperature, the resilient modulus of mix M100 is 110% higher compared to that of mix M0.

The creep modulus of mix M100 is four times higher than that of mix M0. However, the improvement trend for mix M25, M50 and M75 is not consistent. In general, incorporation of GCS aggregate in asphaltic concretes significantly improves the dynamic creep modulus of the mixes. Mix M100 exhibits the highest resistance for both short term and long term creep rate. The cumulative strain of mix M100 is 15% higher compared to Mix M0. The improvement in short term rut rate is not significant. However, mixes incorporating 100% GCS aggregate exhibits better long term rut rate compared to mix with 100% normal shaped aggregate.

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CONSTRUCTION SUPPLY CHAIN MANAGEMENT PRACTICES IN MALAYSIA

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Abstract
Supply Chain Management (SCM) application has been investigated as an effective management strategy to improve performance in many industries. Meanwhile, construction projects suffer from high fragmentation, large waste, poor productivity, cost and time overruns, and conflicts and disputes for a long time. Though SCM has the potential to alleviate these problems significantly, SCM initiatives in construction have been partial—covering a subset of issues in a limited part of the construction supply chain. This paper presents the findings of a Construction SCM (CSCM) study from the Malaysian construction perspective. The main objectives of this study were to, 1) identify the SCM practices, and 2) explore the level of adoption and practice of these identified SCM practices in the Malaysian construction industry. A mixed-mode approach was adopted through structured questionnaires and interviews with the main construction industry players, namely the contractors, developers, and suppliers, where the gathered data was analysed to accomplish the main objectives.From the study, the results were framed against the Strategic Thrusts as provisioned by the Construction Industry Master Plan (CIMP) as released by the Construction Industry Development Board (CIDB). The major issues related to the adoption and practice as discussed by the industry players regarding SCM practices in the Malaysian construction industry revolve around six major areas: human resource management; equipment and technology; collaboration practices; construction materials; green practices; and operating environment.

Keywords: *Construction; Supply Chain Management; Level of Adoption; Level of Practice Malaysia*

INTRODUCTION

The construction industry is critical for national wealth creation as it is a strong catalyst for the development of other industries, like manufacturing, professional services, financial services, education, and many others (Sundaraj, 2006). The number of contractors involved in the industry is continually increasing. However, the 7th and 8th Malaysian Plans (Economic Planning Unit, The Prime Minister's Office, 2001) reported that about five per cent of projects were not able to be completed due to various cited reasons. Therefore, there is a great interest to find out the factors that contribute toward these failures amongst the key players within the construction industry, especially with the emphasis on the current thrust of the Supply Chain Management (SCM) context.

Like its counterparts in many countries of both developed and developing nations, the construction industry in Malaysia is similarly characterised by fragmentation and poor co-ordination by participants that lead to inefficiency, waste, quality, and safety problems (Xue, Wang, Shen, & Yu, 2007). Moreover, inadequate attention is provided for the environment where players see responsibility as lying with others (Ofori, 2000). One of the major problems facing these key players is to keep on sustaining their

competencies to face the growing challenges in this industry. In addition, these players also need to develop their abilities and capabilities in managing their organisations in order to continually improve the efficiency of their activities in this industry. It is suffice to say that this improvement is paramount in the face of stiff competition both by local rivals as well as from abroad in this era of globalisation.

Until now in construction, initiatives belonging to the domain of SCM have been rather partial (Oyegoke, Khalfan, &Maqsood, 2011), covering a subset of issues, such as transportation costs, in a limited part of the construction supply chain, such as the construction site. In most cases, the issues are regarded from a main contractor's point of view (Asplund& Danielson, 1991; Wegelius-Lehtonen, Pahkala, Nyman, Vuolio, &Tanskanen, 1996). The construction industry product is of the nature of an investment service where the customer wields great influence on the final product in relation to its physical aspects (dimensions, application of materials, etc.) and the value of logistic parameters (delivery date, project duration, etc.). In some cases, the customer selects the manufacturer (contractor), the suppliers of specialist parts, and the material suppliers (Kornelius&Wamelink, 1998).

Thus from the perspective of long-term relationships that is encouraged in SCM, efficient supplier-contractor relationships are vulnerable to disruption in this context. Meanwhile, Bontekoe (1989) developed a list of 10 bottlenecks that hamper the application of logistics in construction which may also be applicable in the SCM context. Some of the more critical bottlenecks include a need for extensive preparation for approval procedures, conflicts of interest between organisations within project organisation, and a need for co-operation with public utilities.

Nowadays, enterprises are facing an environment changing at an increasing rate which forces them to adapt to change by introducing new approaches to business management. In the logistics area, a significant degree of innovation has been observed because of the increasing complexity and dynamics of markets. However, the construction industry has been slower than other industries in adopting new management strategies and there is relatively little evidence of the application of good SCM practices in this area (Telhada, Pinho, &Carvalho, 2008). Empirical experiences addressing SCM in construction have been reported (Vrijhoef&Koskela, 2000), and, since the construction industry is the largest industrial sector in the world accounting for approximately 10 per cent of the global gross productive effort (O'Brien & Al-Biqami, 1998), it seems that there is a great potential for improving.

A number of alternative procurement approaches and forms of contract have emerged since the 1960s in response to the changing needs of construction's more informed clients and as a growing realisation of the inherent problems of the traditional route (O'Brien, Formoso, Vrijhoef, & London, 2010). These alternative procurement strategies, which include "Two-stage Competitive Tendering", "Design

and Build", "Management Contracting", and "Construction Management" represent some differences in relationships, roles, and power between the design and cost consultants and main contractor, and between the main or managing contractor, and the specialist and trade subcontractors (Edum-Fotwe, Thorpe, &McCaffer, 2001). As can be seen in the literature, these new approaches have resulted in some potential for greater collaboration and integration (Abdullah, Othman, &Zulhumadi, 2010). This is especially so with the introduction of the industrialised building system (IBS) (Nawi, Lee, Kamar, & Hamid, 2011), attempts to integrate the production and SCM aspects of the manufacturing sector into the construction industry.

However, a number of authors remain critical of main construction player's attempts to reshape these approaches. This suggests that the construction industry lacks a systematic and strategic approach to change which can be seen as impeding the cumulative and evolutionary aspect of SCM relationships—a key aspect of "fifth generation innovation"(Rothwell, 1994). Also, the construction industry has been observed to be slower in employing the SCM concept, which has been widely embraced elsewhere in other industries. This is because of the unique context in which SCM collaboration must be applied, i.e. an organisational structure consisting of individual elements in the nature of a conglomerate, termed "the temporary multiple organisation" (Cherns& Bryant, 1983).

The full integration of the supply chain should boost the efficiency and effectiveness across all supply chain members. This aspect is most relevant to construction. Thus SCM should be considered as essential to the performance and competitiveness of the construction enterprise considering the variety of materials, products, and components it requires on each project; the range of subcontracting companies it normally engages; and the variety of consultants it works with, sincethe traditional approach to business has several discernible and detrimental elements associated with it. Amongst these include, win and lose arrangements; a focus on negative issues; uncertainty; a minimal exchange of information; the buying of supplies of each item from many companies to maintain price competition; and an atmosphere of fear, dishonesty, and frustration. It is due to the above described scenario that this research endeavour was undertaken.

Therefore, several objectives where prescribed for this research effort. These objectives are as follows:

1. To identify the SCM practices that were used by the Malaysian construction industry players; and
2. To establish:
    a. The level of adoption of the identified practices, and
    b. The level of practice of the identified practices of these industry players in the Malaysian construction industry.

In order to place the boundaries of this research, the scope of this research was further discussed and confirmed through in-depth focus group discussions with representatives from the industry. This research was to be performed within the construction industry of Malaysia, where the involved respondents were identified as being categorised as one of three identified categories, namely contractors, developers, and suppliers.

METHODOLOGY

A balanced approach was taken via two phases, namely the qualitative and quantitative path. The qualitative path was firstly taken via a series of interviews with the main identified players in the construction industry via the recommendations of the Construction Industry Development Board (CIDB), a body that oversees the construction industry in Malaysia. Each of these interviews were performed on site of the respondents' company and most lasted over two hours in length, using the semi-structured interview approach. This data collection effort yielded in 13 interviews that were recorded, transcribed, and analysed.

Through a data organisation process using the NVIVO software, an initial framework was developed, which was verified with two sources of expertise, namely the verified and published literature, and the experts in both the industry and academia. As a result, the final framework was produced. A further in-depth literature search was performed focussing on the 15 SCM practice dimensions (see Figure 1) and two performance dimensions of the questionnaire in order to obtain the relevant question items which were to be presented in the next phase of this research, namely the quantitative phase. It should be noted here that every step of the qualitative process had a verification procedure with experts in order to validate the final version of the questionnaire, which was used in the survey.

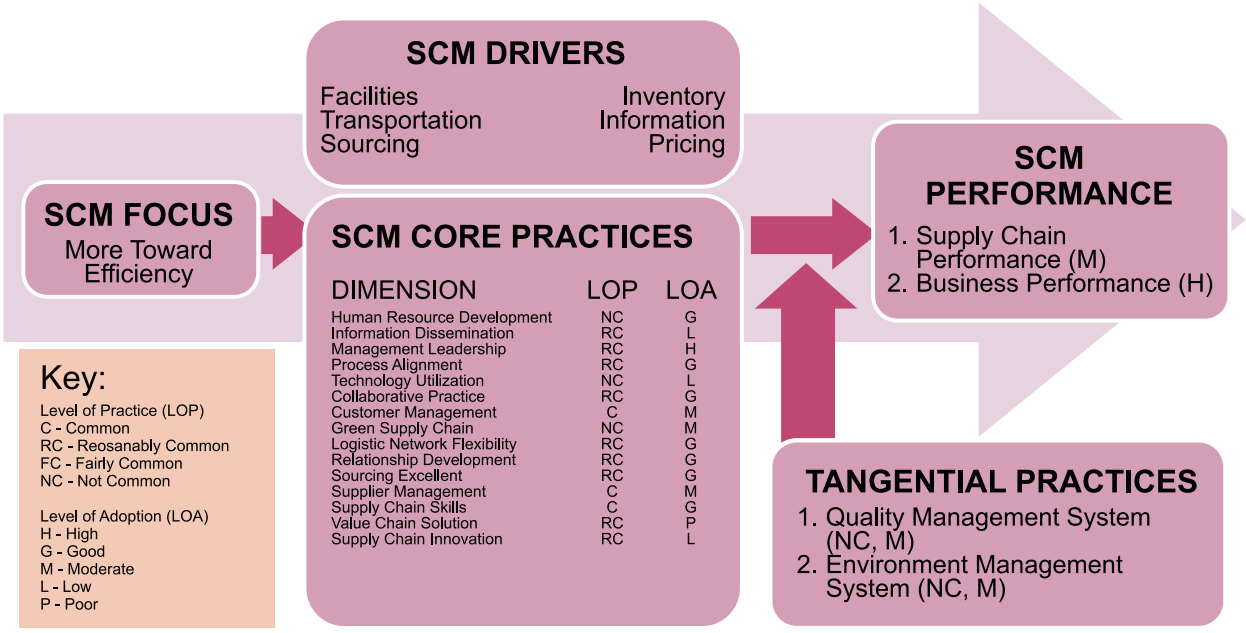

Figure 1. Existing SCM practices – The Malaysian construction industry's perspective

Respondents for the survey conducted in this study covered all categories of players in the Malaysian construction industry, namely the contractors, developers, and suppliers. It was anticipated that a normally distributed research questionnaires by post, as normally carried out for a general survey, would pose some response problems. The reasons for this are two folds.

Firstly, the overall SCM concept has not been established in construction industry world, especially in the Malaysian context, and respondents may have difficulty in understanding the items and concepts that are presented. As such, assistance was found necessary in answering the questionnaire.

Secondly, from previous experience, the response for a questionnaire-related survey is poor at best, even for simple questionnaire forms and small number of questionnaire items. Questionnaires were distributed during the two CSCM seminars that were organised by CIDB and a total of 45 responses were received. Further responses were obtained through visits to companies which later yielded 13 usable responses. As most of the respondents were not familiar with the supply chain concept, they were guided in answering the questionnaires.In the end, a total of 58 sets of questionnaires were collected, and after reviewing the responses from all respondents, 53 were deemed to be appropriate for further analysis.

RESULTS

In attempting to achieve the objectives of this research, there are several barriers that have to be overcome so that the raw data that have been gathered can be stably, coherently, and validly interpreted. According to Wright and Masters (1982), these barriers that have been identified to include the uncertainty of the relationship between the data gathered with the phenomenon (in this case the practice of SCM) that is to be measured, distortion of the data during the transformation process from the observation (raw data) to conceptualisation (means and aggregates) due to the non-linearity of the scale, confusion resulting from interdependencies due to the complexity of phenomenon under study, and finally the ambiguity related to the non-arbitrary way of investigating which particular definitions of existing entities are the correct ones to take into account. Thus, in the context of our research, Tor (2009) had recommended that social science measurement can be performed indirectly by probabilistic inference.

Therefore, alternative methods were explored in trying to determine how to analyse and interpret the data so that the findings would be generalizable to a certain degree. After reviewing two different theories relating to the approach in scaling and measurement (i.e. to estimate the reliability and validity of the empirical instrument), namely traditional test theory and modern test theory, as well as taking into consideration the available data gathered from the survey and the associated limitations, we further investigated the modern test theory route. One viable method down this branch is the Rasch Measurement Model (RMM) (Allerup, 1999) because of its suitability in addressing all the problems that were encountered during our research, as well as overcome the above mentioned barriers. This method works by applying a simple mathematical model which constructs abstract linear measures from the concrete raw data (Tor, 2009).

Another issue that the RMM is capable of addressing is the minimum sample size, which generally reflects the characteristics of the entire population under study. Thus, the issue of sample size ultimately rests on the stability of the respondents in order to obtain useful and concrete data for analysis. According to Linacre (1994) when using RMM, theoretically where an item calibration is the modelled standard error (SE), "as a rule of thumb, at least 8 correct responses and 8 incorrect responses are needed for reasonable confidence that an item calibration is within 1 logit of a stable value".

Table 1. Recommended sample sizes for using RMM technique

Item Calibrations Stable Within	Confidence Level	Minimum Sample Size Range	Recommended Size for MostPurposes
± 1 logit	95%	16 – 36	30
± 1 logit	99%	27 – 61	50
± ½ logit	99%	64 – 144	100
± ½ logit	99%	108 – 243	150
Definitive or High Stakes	99%+ (Items)	250 – 20xtest length	250

(Source: Linacre, 1994)

This translates to a 95% confidence level for stable item calibrations within ±1 logit value. For a more precise measurement, in other words a 99% confidence level, a minimum sample size range would be between 27 to 67 is required, which is calculated using the formula 4xSE2< n < 8xSE2 where the SE value for a two-tailed 99% confidence interval is ±2.6 logits.Table 2.2 summarises various recommended minimum sample sizes in relation with the confidence level. From the survey, 53 responses were appropriate for further analysis using the RMM technique. Based on Table 1, this sample size would give a 99% confidence level with stable item calibrations within ±1 logit value.

The RMM system works around the transformation of an ordinal set of data into a probabilistic model. Principally, raw data was initially translated along the rubric of Logit Ruler's continuum, which is described in Table 2, and further analysis was performed in order to determine the Level of Adoption (LOA) and Level of Practise (LOP) of the respondents regarding each component.

Table 2. Logit ruler description – Mean assessments

No.	Item	Type of Survey Question	Terms	Descriptions
1	SCM Practice	Inclination to Practice (Yes or No)	• Yes	• Positive toward SCM practices
			• No	• Negative toward SCM practices
2	SCM Practice	Intensity level of practices (1 (Low) – 4 (High))	• Mean(-ve) Logit (Person)	• Unlikelihood of correspondents practising good SCM practice
			• Mean(0.00) Logit (Person)	• 50/50
			• Mean(+ve) Logit (Person)	• Likelihood of correspondents practising good SCM practice
			• Mean(-ve) Logit (Item)	• Likelihood that overall Items are commonly practised or able to be practised
			• Mean(0.00) Logit (Person)	• Zero Setting
			• Mean(+ve) Logit (Item)	• Likelihood that overall Items are not commonly practised or unable to be practised

The LOA refers to as the likelihood that the practice is consistently adopted. In general, RMM operation has revealed that the construction players can then be categorised into five categories of adopters as described in Table 3.

Table 3. Description of LOA

Category Name	Description
High Adopters (H)	View practices as very important and very easy to adopt
Good Adopters (G)	View practices as important and find it easy to adopt
Moderate Adopters (M)	View practices as more or less important and more or less easy to adopt
Low Adopters (L)	View practices as less important and less easy to adopt
Poor Adopters (P)	View practices as not important and not easy to adopt

The distribution of respondents along the five categories of LOA in Table 3 was tabulated from visual classifications of Person Map translated by RMM analysis in line with Item Separation stipulated by the RMM regression (Figure 2).

The study had revealed that for the LOA, the ranking for SCM practices is summarised in Table 4 (as well as previously in Figure 1). This table shows that the top ranked SCM practice being the Management Leadership dimension (with High LOA), while the lowest ranked is the Value Chain Solution (with Poor LOA). There are seven practices which have Good LOA, three Moderate LOA, and three Low LOA.

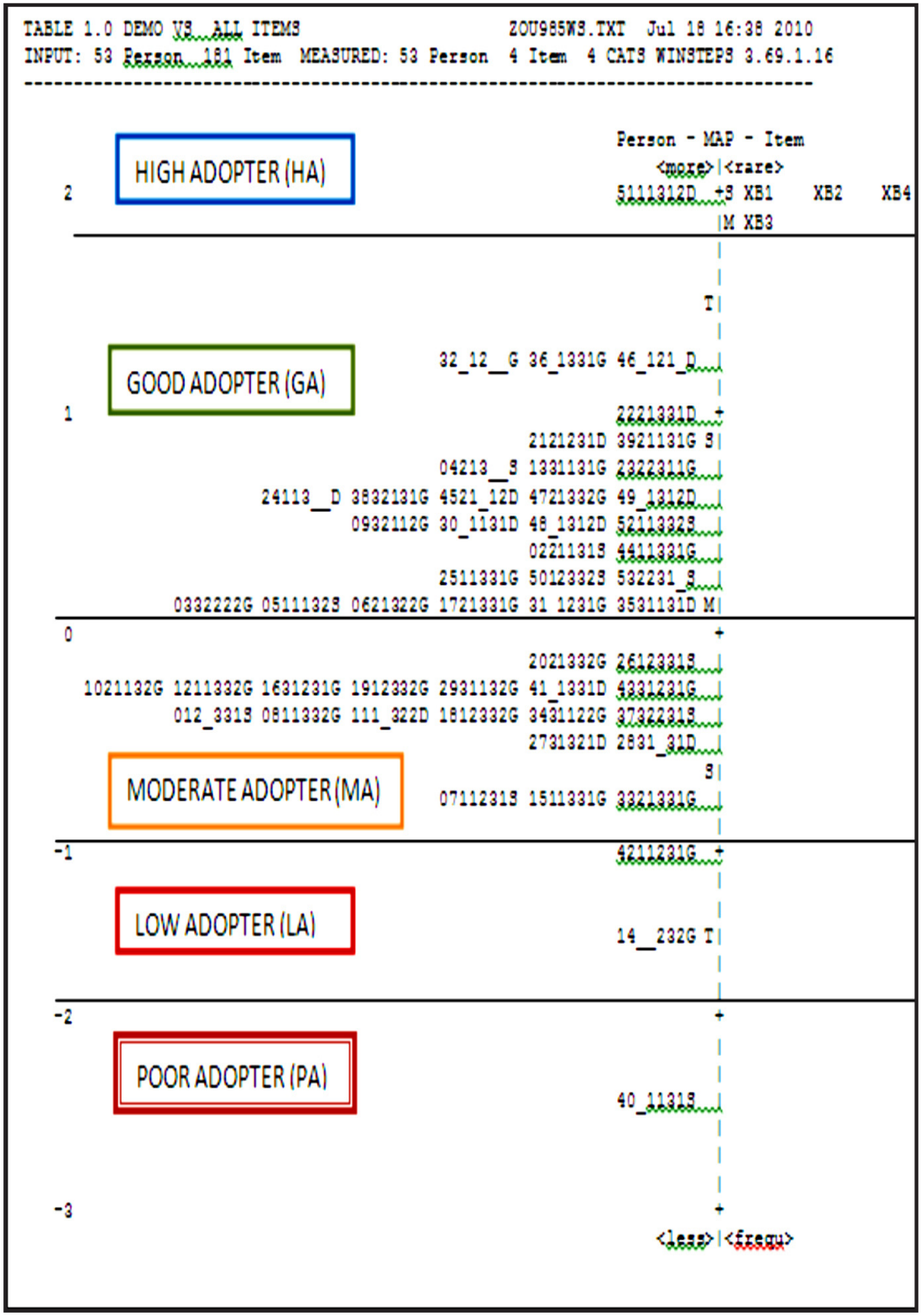

Figure 2. Example of RMM output

Table 4. Ranking of overall SCM core practices according to LOA

No.	SCM Core Practice	LOA
1.	Management Leadership	High
2.	Supply Chain Skills	Good
3.	Relationship Development	Good
4.	Sourcing excellence	Good
5.	Logistic Network Flexibility	Good
6.	Process Alignment	Good
7.	Collaborative Practice	Good
8.	Human Resource Development	Good
9.	Customer Management	Moderate
10.	Supplier Management	Moderate
11.	Green Supply Chain	Moderate
12.	Information Dissemination	Low
13.	Supply Chain Innovation	Low
14.	Technology Utilisation	Low
15.	Value Chain Solution	Poor

Meanwhile, LOP refers to the intensity level of practices. The SCM practices can be categorised into four main categories as shown in Table 5. The distributions of practices along the four LOP classifications were tabulated along the likelihood of practice extracted from the RMM analysis. These figures (percentages) were converted from logit score for each item by using the Rasch calculator.

Table 5. Description of LOP

Category Name	Description
Common (C)	High percentage of dimensions practised (x>70%)
Reasonably Common (RC)	Reasonably high percentage of dimensions practised (40%<x<70%)
Fairly Common (FC)	Low percentage of dimensions practised (20%<x<40%)
Not Common (NC)	Very low percentage of dimensions practised (x<20%)

From the RMM analysis, respondents involved in this study are attached to the following attributes: high reliability (between 95%-99%), and probability rate of successfully practising all dimensions referred to in this research throughout the Malaysian construction industry of 52.75%. This finding generally transcribes that SCM is a reasonably common philosophy moderately adopted by players in the Malaysian construction industry.

From the aspect of LOP, the study also revealed that the industry players adopt the SCM practices along the 15 dimensions surveyed and ranked, as summarised in Table 6 and Figure 1 (from Common to Not Common).

Table 6. Ranking of overall SCM core practices according to LOP

No.	SCM Core Practice	LOP
1.	Customer Management	Common
2.	Supplier Management	Common
3.	Supply Chain Skills	Common
4.	Relationship Development	Reasonably Common
5.	Sourcing excellence	Reasonably Common
6.	Logistic Network Flexibility	Reasonably Common
7.	Process Alignment	Reasonably Common
8.	Management Leadership	Reasonably Common
9.	Collaborative Practice	Reasonably Common
10.	Value Chain Solution	Reasonably Common
11.	Information Dissemination	Reasonably Common
12.	Supply Chain Innovation	Reasonably Common
13.	Human Resource Development	Not Common
14.	Green Supply Chain	Not Common
15.	Technology Utilisation	Not Common

From Table 6, it can be observed that the most commonly practiced dimensions of SCM core practices are related to the customer and supplier management, as well as the supply chain management skills (all of which were revealed to be a common practice). However, the human resource development, green supply chain, and technology utilisation were revealed to be the least commonly practiced dimensions.

These tables were then inspected further to breakdown the findings according to the three identified main players in the construction industry, namely the developers, contractors, and suppliers. The summary of the LOA and LOP can be found in Table 7 and Table 8, respectively.

Table 7. Ranking of overall SCM core practices according to LOA by best practice players

No.	SCM Core Practice	Developers	Contractors	Suppliers
1.	Human Resource Development	H	G	G
2.	Information Dissemination	G	G	G
3.	Management Leadership	H	H	H
4.	Process Alignment	H	H	H
5.	Technology Utilisation	G	M	M
6.	Collaborative Practice	H	G	G
7.	Customer Management	H	G	G
8.	Green Supply Chain	M	M	M

9.	Logistic Network Flexibility	H	G	G
10.	Relationship Development	H	G	G
11.	Sourcing excellence	H	G	G
12.	Supplier Management	H	G	G
13.	Supply Chain Skills	H	G	G
14.	Value Chain Solution	H	H	H
15.	Supply Chain Innovation	G	G	G

Table 8. Ranking of overall SCM core practices according to LOP by best practice players

No.	SCM Core Practice	Developers	Contractors	Suppliers
1.	Human Resource Development	RC	FC	FC
2.	Information Dissemination	C	C	RC
3.	Management Leadership	C	C	C
4.	Process Alignment	C	C	C
5.	Technology Utilisation	FC	NC	NC
6.	Collaborative Practice	C	C	C
7.	Customer Management	C	C	C
8.	Green Supply Chain	FC	FC	NC
9.	Logistic Network Flexibility	C	C	C
10.	Relationship Development	C	C	C
11.	Sourcing excellence	C	C	C
12.	Supplier Management	C	C	C
13.	Supply Chain Skills	C	C	C
14.	Value Chain Solution	C	C	RC
15.	Supply Chain Innovation	C	RC	RC

From Table 7 and Table 8, it can be surmised that the Developers are the main industry players who are high adopters and common practitioners of most of the SCM practices, while the suppliers are relatively lower adopters and less common practitioners of the SCM practices investigated in this study.

DISCUSSION

In general, major issues related to adoptions and practices discussed by the industry players regarding SCM practices in the Malaysian construction industry revolve around six major areas of concern. These six major areas can be discussed drawn from the framework established by the Construction Industry Master Plan (2006-2015) that was published by the Construction Industry Development Board (CIDB, 2008). The seven main Strategic Thrusts (STs) or objectives that were recommended are:

1. To integrate the construction industry value chain to enhance productivity and efficiency (ST1);
2. To strengthen the construction industry image (ST2);
3. To strive for the highest standard of quality, occupational safety and health and environmental practices (ST3);
4. To develop human resources capabilities and capacities in the construction industry (ST4);
5. To innovate through research and development and adopt new construction methods (ST5);
6. To leverage on ICT in the construction industry (ST6); and
7. To benefit from globalisation including the export of construction products and services (ST7).

Meanwhile, from the research, the following six areas of concern were identified:

1. Human Resource Management (HRM);
2. Equipment and Technology (ET);
3. Collaboration Practices (CP);
4. Construction Materials (CM);
5. Green Practices (GP); and
6. Operating Environment (OE).

Therefore, the discussion of this paper is framed according to the CIMP Strategic Thrusts, as shown in Table 9.

Table 9. Matrix showing the link between the CIMP framework and the research results

Results Areas / Strategic Thrust	HRM	ET	CP	CM	GP	OE
ST1		✔				
ST2			✔			
ST3					✔	✔
ST4	✔					✔
ST5			✔	✔		
ST6		✔		✔		
ST7		✔		✔		

Human Resource Management

Basically, through corroboration from the interviews and survey results, human resource has surfaced as an important aspect, as viewed from the following perspectives:

(i) In terms of **leadership**, lack of top management support in committing to SCM practices is a critical issue (Spekman, Kamauff, &Myhr, 1998). Usually when involving contractors, the financial aspect of operations is the main reason for this paucity. Leadership is not focused since SCM in most organisations is a shared function, and this impedes the progress of SCM as a strategic agenda. This also means that there are almost **no dedicated personnel or functions** for construction SCM.

(ii) Appropriate SCM **training and development** programmes (Mangan&Christopher, 2005), especially skills to manage SCM, have been lacking. Most training issues revolve around technical and accounting system improvement. This was caused by **negative behavioural attitudes** that are not ready for change since they still believe that there is no harm in the existing practice. Most individuals involved in construction SCM are not strategic thinkers and are comfortable with conventional practices.

Equipment and Technology

Respondents involved pointed out that the following perspectives need to be addressed:

(i) **Process technology** is important to help accelerate processes in SCM, such as procurement, production, and distribution, which help improve quality and delivery

time to customers (Lambert, García-Dastugue, &Croxton, 2005). However, at this juncture, process technology in construction SCM is believed to be affected by high operating cost, low-skill workers, and little management commitment.

(ii) **Information technology** is an enabler to successful adoption of SCM (Subramani, 2004). For that, top management should champion the need of IT infrastructure development, such as Electronic Data Interchange (EDI). However, this does not happen in the lower half of the industry. In today's global environment, organisations should prepare appropriate IT infrastructure such as local network, the Internet, database system, and multimedia devices that are required for enterprise IT as the platform to support CSCM development. However, the study revealed an absolute contradiction in terms of existing practices. Most respondents agreed that technology helps enhance SCM practices by enabling flexibility, but at present, sharing the same system among all entities is still considered an unfavourable move.

Collaboration Practices

Collaboration further accelerates the momentum of SCM implementation in the industry. From the study, it was revealed that:

(i) The issue of **trust and openness** is one of the main barriers in terms of collaboration (Akkermans, Bogerd, &van Doremalen, 2004). Elements of the business relationship, for example, credit facility between all entities within the value chain, are always based on long-term relationships. In many cases, it is evidenced throughout the entire industry player categories that financial capability governs most of the SCM decisions than compared to trust.

(ii) Most entities do not share **common interest** in terms of developing each other's capabilities and potential (Barratt, 2004). In many interview sessions, respondents pointed out that the common practice circles around one ultimate issue, namely individual profit maximisation. Cross-company efforts to problem-solving do not occur in the lower end of all industry player categories. The pressure of discounting leads to an oppressively ordained environment. According to information disclosed by one of the respondents from the eastern region, each player involved throughout the supply chain tends to be highly individualistic rather than accommodative in terms of cross-company cost reduction initiatives.

(iii) **Nominated supplier** issues often drives contractors toward building new relationships with new suppliers (Twigg, 1998; Jüttner, 2005). From the contractor perspective, this new relationship will not benefit them in terms of credit cycle, as compared to long-term suppliers.

Construction Materials

Many of the respondents believe that the following issues must be highly considered and addressed:

(i) From the **price and distribution** aspect, industrial practice functions where most suppliers are graded by their ability to deliver low price materials, but with high degree of unhealthy compromise. In some cases, SCM practices related to conventional materials in construction SCM is controlled by rooted and traditional channels of distribution all around the industry. This would be detrimental in some instances, and would result in project overruns or project defaulting.

(ii) Decentralisation of operations, global outsourcing, and **strategic alliance** are some alternatives taken by counterparts in a more developed environment for gaining greater flexibility, faster speed, and reduced time to market (Whipple & Frankel, 2000; Tan, Lyman, &Wisner, 2002). However, most Malaysian industry players still practise arms-length and adversarial approaches. At the higher end, specialists, manufacturers, and suppliers may form a consortium or a team-working agreement. However, at the other end, most of the construction material games are inadvertently played, especially when a nominated supplier is concerned.

(iii) Conventionally, material incubation into the design has always been dictated by the architects and engineers. Lack of contractors and suppliers **involvement at the early stage**, especially during the conceptual stage, makes the SC process in construction more complicated.

Green Practices

Besides the above mentioned points, the respondents involved in the study had highlighted problems that hinder the development of green practices in the Malaysian construction SCM. At present, green practices are **not made compulsory** by most of the clients, thus there is not enough pressure to adopt. If there is a request, then the client would have to bear total costs.

Thus green SCM is still at an infancy stage, still far from a reality, as with the case of other countries (Zhu, Sarkis, &Geng, 2005) where perhaps the awareness is high, but the implementation is still lacking. In many instances, the enforcement is not feasible since certain situations would force the company to deal with "non-green" suppliers due to lack of options.

Although knowledge-wise the construction industry players are aware of the green ruling index and about green practices as well as materials, they are reluctant to implement it as an advantage in their operations since the market for green materials is still small when compared to their counterparts in the more developed countries,

and thus it would be less profitable for them to implement when compared to adopting non-green practices.

Operating Environment

The study also revealed that the operating environment also contributes significantly toward the inefficiency of the SCM practices in the Malaysian construction industry. Some of the issues can be viewed as follows:

(i) At the **higher education** level, there are no specific universities that offer specific SCM programmes specifically for the construction environment, thus leading to the missing link between operational and strategic levels of construction SCM implementation. Previous study had highlighted the need for logistics and supply chain education to be introduced in the production of quality human capital, especially from the SCM perspective (Gammelgaard& Larson, 2001).

(ii) One reason that impedes construction SCM practices is the **nature of the projects**, which involves unique and non-routine mobile projects. The mobility factor contributes to having a small number with long-term commitments in terms of collaboration between the developers-contractors-suppliers.

Therefore, as a result of the above discussion and findings, the construction industry at present, can be said to have different degrees of readiness when it comes to the different construction supply chain practices. After reviewing the combination of LOP and LOA for each practice dimension(thus producing the description related to level of readiness in Table 10) with regard the readiness of the industry, the analysis revealed the final ranking as shown in Table 11.

Table 10. Description of level of readiness (LOR)

Category Name	Description
Ready (R)	High percentage of dimensions is readily accepted (x>70%)
Reasonably Ready (RR)	Reasonably high percentage of dimensions is readily accepted (40%<x<70%)
Fairly Ready (FR)	Low percentage of dimensions is readily accepted (20%<x<40%)
Not Ready (NR)	Very low percentage of dimensions is readily accepted (x<20%)

Table 11. Ranking of SCM core practices according to level of readiness

No.	SCM Core Practice	Level of Readiness
1.	Supply Chain Skills	Ready
2.	Management Leadership	Ready
3.	Customer Management	Ready
4.	Supplier Management	Ready
5.	Relationship Development	Ready
6.	Sourcing excellence	Ready

7.	Logistic Network Flexibility	Ready
8.	Process Alignment	Ready
9.	Collaborative Practice	Ready
10.	Information Dissemination	Reasonably Ready
11.	Supply Chain Innovation	Reasonably Ready
12.	Human Resource Development	Reasonably Ready
13.	Value Chain Solution	Reasonably Ready
14.	Green Supply Chain	Reasonably Ready
15.	Technology Utilisation	Fairly Ready

From Table 11, it can be observed that nine out of the 15 practice dimensions surveyed during this study is either common or highly practiced in the Malaysian construction industry, and thus can be readily accepted by the players of the industry. However, one of the main areas of concern, that is technology utilisation, still requires further development and attention from all parties involved.

CONCLUSION

This research has looked into the practice of SCM in the Malaysian construction industry. The motives behind this study were to identify the pertinent dimensions involved in SCM practices among three fraternities of construction industry players, namely contractors, developers, and suppliers. Besides that, this study also went deep into acknowledging the level of intensity of each practice in order to gain a thorough understanding on related issues.

For the purpose of this study, raw data was gathered through two ways: field survey and interview. Due to some limitations and the nature of the industry itself, the data and information gathered were then analysed by using Rasch Measurement Model (RMM) to translate into general terms in line with the research objectives. From the study, it was discovered that, in general, SCM is a reasonably common practice within the construction system in this country. For all 17 dimensions surveyed, it can be translated that each of them has its own significant values along the SCM practices and strategies. Some of the item means (representations of dimensions reviewed) stand along the midway of the Logit Ruler (a gauge of probability measure) which translates the dimensions' complexity in practice. However, most of them reflect a favourable acceptance among the construction fraternity.

Respondent-wise, the RMM instrument used in analysing the survey illustrates that there are explicitly clear separations among total respondents in terms of adoption levels. In many of the variables involved in the study, most of the respondents fall into the Moderate Adopter category, while only a very small number (1.89%) can possibly be referred to as high performers.

Overall, in terms of adoption level, the industry players have moderate to good adoption levels of SCM, while SCM practices are reasonably common in the Malaysian construction industry with 40-70% probability of the industry player to implement SCM in their activities which summarises that SCM is indeed in practice in the construction industry. However, there seems to be a trend where the industry players are more concerned toward implementing selected practices rather than from a more comprehensive perspective.

In the end, this research could serve as a prelude for CIDB and researchers to explore other potential areas related to the SCM, particularly in area of collaborative development, which involve players' capability and commitment to share objectives, responsibilities, risks, and even rewards. Furthermore, the trust development among players also becomes the crucial factor in developing collaboration throughout the construction industry. It should not solely focus on the financial strength factor only, but also in terms of SCM knowledge, information, technologies, and so on, to further strengthen this industry. Another possibility is that CIDB and researchers could work together in conducting other research or study related to the importance of utilising information technologies to enhance the capability of sharing information as a pre-requisite for collaboration. Lastly, the issues of value management, green supply chain, and supply chain innovation which are crucial to the sustainability of the construction industry should not be ignored as well.

Conclusively, this research has been successful in meeting its objectives. Despite having good adoption level of SCM practices, SCM understanding and practices are still rather low. This gives room to further educate the industry players regarding SCM practices with hopes of providing a more sustainable future in the construction industry.

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EXPORT OF MALAYSIA'S CONSTRUCTION PROFESSIONAL SERVICES

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Abstract
Malaysia's services exports can play a greater role in international trade in the future. It is in cognisance of this potential that a study was conducted to examine the internationalisation of Malaysia-based construction-related (i.e. architectural, civil engineering and quantity surveying) firms. The objectives of the study were to investigate certain internationalisation aspects – internationalisation motivations, firm-specific advantages, home country-specific advantages, location factors and methods of securing overseas work – of the sampled firms. Data was collected using the quantitative-qualitative combination of postal questionnaire survey and interviews. It was found that top management decision was the main internationalisation motivation. Service quality and mutual professional recognition were the top firm- and home country- specific advantages respectively. Political stability was the main market entry consideration. Invitations by Malaysian clients and consultants were the most important method of securing overseas work. Aspiring international construction-related consultancy firms from Malaysia and other developing countries can draw inspiration from the study. The study also adds to our knowledge on the internationalisation of services firms which is inadequate compared to manufacturing firms. Studies on multinational firms from developing countries are rare. The paper concludes by making recommendations to consulting firms from other developing countries on matters to consider should they wish to internationalise.

Keywords: *Architecture, Civil Engineering, Export, Firm Internationalisation, Professional Services, Quantity Surveying.*

INTRODUCTION

In the 1980s, few civil engineering professional multinational enterprises from developing countries broke into the western club (Rimmer, 1987). Almost two decades later, construction professional MNEs have managed to make inroads in the international markets (Bradley, 2005). Yet, their progression has not received scholastic attention they rightly deserve, which is a reflection of the broader disinterest of scholars in MNEs from developing countries (Guillaén and García-Canal, 2009). Indeed even governments of developing countries have largely overlooked and not tapped the potential of trade in services (Cattaneo et al., 2010).

Malaysian construction professional firms (covering the civil engineering, architecture and civil engineering disciplines) have likewise been making impact overseas, small as it may be (see Table 1). Acknowledging that trade in services will increase in volume in years to come, the Malaysian government has been taking progressive steps to liberalise the services sector under the ASEAN Framework Agreement for Services (AFAS) and General Agreement on Trade in Services (GATS) with the intention of improving capacity, productivity and efficiency of the services sector so that market openings can be exploited.

Table 1. Selected Malaysian civil engineering, architectural and civil engineering consulting firms that have ventured abroad

Name of firm	Discipline	Countries involved
A+I Design Sdn Bhd	A	Pakistan
Almaz Architect	A	Saudi Arabia, Qatar
Aqidea Architect	A	Libya, Sudan, Abu Dhabi, Algeria,Pakistan
ARH Jurukur Bahan Sdn Bhd	QS	Sudan, Saudi Arabia
Arkitek ICB Sdn Bhd	A	USA, UAE, Thailand
Arkitek Kitas Sdn Bhd	A	USA
Arkitek MAA Sdn Bhd	A	Brunei, Singapore, China
Arkitek N. Kang	A	UAE
Arkitek Pakatan Pertama	A	Australia
Arkitek Urbanisma	A	Albania, Australia, Dubai, Pakistan, Bahrain
Atsa Architects Sdn Bhd	A	Maldives
Aziz, Azizi & Partners Sdn Bhd	QS	Saudi Arabia, Sri Lanka
Azza Associates Architects (Penang)	A	UAE
BW Perunding Sdn Bhd	CE	Syria
Dr Nik & Associates Sdn Bhd	CE	Oman, UAE
Econcos Consultants Sdn Bhd	QS	India
EDP Consulting Group Sdn Bhd	CE	Philippines
EFCT Konsult	QS	China, UAE
ES Raof Arkitek	A	Uganda, Thailand
Focus Architects & Urban Planners Sdn Bhd	A	Zambia, Dubai, Abu Dhabi
G&P Professionals Sdn Bhd	CE	Singapore, Indonesia
Garis Architects sdn Bhd	A	Sudan, Libya,Vietnam, India
GCU Consultants Sdn Bhd	CE	Vietnam
Ihsan Team Consultants Sdn Bhd	CE	Brunei, Indonesia
In-site Design	A	Iran, Libya
JUB Waja	QS	Oman
Jurutera Nusantara Bersekutu Sdn Bhd	CE	Indonesia
Juruukur Bahan H & A	QS	Saudi Arabia, Qatar
Juruukur Bahan Bersama	QS	Saudi Arabia
Kamal Salahuddin Partnership Architect	A	Dubai
KL Integrated Consultants – C&H Engineering JV	CE	Libya, Syria, Pakistan
KPK Quantity Surveyors (Semenanjung) Sdn Bhd	QS	India, Mozambique,Myanmar, Sudan, China, Vietnam, Thailand, Abu Dhabi
Kuantibina Sdn Bhd	QS	India, China
Kumpulan Perunding (1988) Sdn Bhd	A	Iran, Dubai
LBH Architect	A	Philippines, China
LKMD Architecture Sdn Bhd	A	Saudi Arabia, Qatar
MCM Associates Sdn Bhd	QS	Australia
Perunding NFL Sdn Bhd	QS	Vietnam
Pintar Jurutera Perunding	CE	Singapore
Putra Konsult Sdn Bhd	CE	Papua New Guinea

PY Konsep Perunding Sdn Bhd	CE	Brunei
Perunding Atur Sdn Bhd	CE	Vietnam, India, Indonesia, Libya
Raja Nazrin Architects Sdn Bhd	A	Brunei, India, Maldives
RDA Harris Architects	A	Morocco, Pakistan, Qatar, Abu Dhabi
Saiful Esa & Associates	A	Qatar, Saudi Arabia, Bangaldesh, Maldives
Teras Prinsipal Sdn Bhd	CE	Philippines
Titijaya Sdn Bhd	A	UAE
T. R. Hamzah & Yeang	A	Saudi Arabia, Kuait, China, Switzerland, France, India, Abu Dhabi, Bahrain, Vietnam, Singapore
T. S. Yee & Associates	CE	Myanmar
Zone Architect	A	UAE, Oman

Source: PSDC (2008).

In 2002, the Professional Services Development Corporation (PSDC) was formed to assist the services sector (including professional services in the construction industry) to enhance the capability and capacity of the Malaysian professionals and professional services firms to global competitiveness (inexplicably, PSDC was dissolved quite recently).

In line with the emergence of Malaysian construction professional MNEs combined with the Malaysian government's aspiration for the services sector, a study was conducted to examine them. Firm internationalisation is a complex process; there are so many aspects that contribute to the internationalisation of firms. This is reflected in diverse models that have been produced (Dunning, 1988; Porter, 1990; Oviatt and McDougall, 2005). Concomitantly various aspects were examined. Specific objectives of the research were:

1. To examine the motivations for internationalising of Malaysian civil engineering, architectural and engineering consultancy firms.
2. To investigate their firm-specific competitive advantages.
3. To examine their home country-specific competitive advantages.
4. To scrutinise the location factors they considered before making market entry.
5. To investigate their methods of obtaining overseas work.
6. To determine if there is any variation in responses between the architectural, civil engineering and quantity surveying firms.

This paper stands to contribute to our understanding of professional services firms, especially those from developing countries. The paper concludes by making recommendations to aspiring construction-related consultants from other developing countries for them to launch their own internationalisation trajectories.

LITERATURE REVIEW

The emergence of MNEs can be attributed to top management (Oviatt and McDougall, 2005). There are various motivations to internationalise: top management decision, unexpected opportunities, existing clients' invitation, firm image, firm growth, anti-business cycle, home government support and competitors' move. The move to internationalisation or otherwise can be eventually traced to top management judgement (Axinn and Matthyssens, 2002). Despite positive conditions, top management may still be inhibited to internationalise by perceived internal limitations (Cort et al., 2007). On the other hand, pro-export top management may choose to ignore the complexities of internationalisation in their enthusiasm to expand abroad (Axinn, 1988). Professional services firms can internationalise from unexpected opportunities (Freeman and Sandwell, 2008). Service firms may internationalise by following clients who have internationalised, building upon domestically developed cooperation (Erramilli and Rao, 1990). To improve firm reputation (Ling, 2005), sustain firm growth (Olson and Wiedersheim-Paul, 1978) and increase firm profit (Leonidou et al., 2007) may drive top management to internationalise. Being in different countries with asynchronous business cycles makes commercial sense (Albaum et al., 2004). The desire to exploit firm resources can stimulate internationalisation (Winstead and Patterson, 1998). Services firm may internationalise as a result of home government support (Cavusgil and Yeoh, 1994). Terpstra and Yu (1988) found competitor following can be the driver for internationalisation.

Firms need to have firm-specific competitive advantages if they are to meet head-on challenges from domestic as well as other foreign competitors in host countries (Dunning, 1988). Quality of service is important because of the intangibility nature of services (Ling, 2005). With people-embodied services, experienced and capable workforce is crucial for overseas success (Schneider and Frey, 1985). Having effective working relationship with clients is one of the most important assets for professional service firms (Cooper et al., 2000). It can even provide overseas opportunities for them. Innovative work processes and ideas have been linked to internationalisation (Bloodgood et al., 1996). Solid reputation is another firm-specific competitive advantage that is crucial to services firms, fragile it may be (Dollinger et al., 1997). Competitive pricing may be used to undercut competitors (Cort et al., 2007). Top management may perceive ISO certification as offering an important competitive advantage (Withers and Ebrahimpour, 2000). For certain locations such as European Union nations, having certified quality management system is a necessity (Erel and Ghosh, 1997). Large financial outlay may be a pre-requisite to making an impact overseas (Gunham and Arditi, 2005).

Home country features can also provide competitive advantages to the firm (Dunning, 1988; Porter, 1990). Mutual recognition of professional qualifications agreements between countries facilitate cross-border activities of affected firms

(Zampetti, 2000). The image of a country can influence the purchasing pattern of foreign service purchasers (Javalgi et al., 2001). A well developed and competitive industry results in firms capable of taking on overseas challenges (Sakakibara and Porter, 2000). Countries belonging to certain economic or even political groupings can have an influential internationalisation effect on their services firms (Plummer, 2006). A strong outwardly oriented political leader can provide the catalyst for internationalisation (Awil and Abdul-Aziz, 2005). Rapid economic development can lead to outward investment (Liu et al., 2005). Professionals coming from multicultural and multiracial societies can easily adapt working abroad (Wilkinson and Cheng, 1999). In fact the lack of understanding of the cultural differences between countries has been the cause of many business failures (Steenkamp, 2001).

The decision to enter a particular host country may be influenced by locational factors (Dunning, 1988). Political stability has been found to be one of them (Seung et al., 2005). A country devoid of law and order is bound to deter foreign companies (Cavusgil and Zou, 1994). Market growth (Koch et al., 2001) and market size (Yoshida, 1987) provide an indication of the opportunities in the host country. The level of domestic (Sullivan and Bauerschmidt, 1990) and foreign (Gorecki, 1976) competition in host countries however can dampen market entry interest. Having the financial freedom to repatriate profits home is also another important consideration (Czinkota, 2000). So are foreign direct investment laws and regulations (Leonidou et al., 2007) and capital requirements (World Bank, 2000) which can serve to attract or dampen foreign business interests. For professional firms, rules and regulations on professional qualifications (Winstead and Patterson, 1998) and visa requirements (Bradley, 2002) can act as barriers to market entry. Physical distance of host countries can deter businesses from servicing them (Leonidou et al., 2007), but air connection (Bruekner, 2003) and common language and culture (Johanson and Vahle, 1977) can mitigate it. Business interaction between home and host countries reduces unfamiliarity (Håkansson and Snehota, 1995).

There are various ways of obtaining foreign work. Services firms traditionally get invited by clients or consultants to work abroad, which they sometimes accept reluctantly simply to safeguard the relationship (Vandermerwe and Chadwick, 1989). Referrals through third parties such as affiliates or sister companies are also important sources of overseas orders (Hinttu et al., 2004). Projects can be secured following international tenders and international competition (Segal-Horn and Dean, 2007). Service firms may also actively seek foreign markets on their own (Erramilli and Rao, 1990). Knowledge process outsourcing whereby knowledge-related and information-related work is carried out by workers in a different company in an offshore location provides another means of obtaining foreign work (Kee and Robbins, 2003). Trade exhibitions (Dekimpe et al., 1997) and trade delegations (Leonidou et al., 2007) are effective product promotional events. Detailed citations of the five broad aspects are shown in Table 2.

Table 2. Sources of reference

Variable	Source
Motivation to internationalise	
Top management decision	Axinn (1988), (Reid (1981), Axinn & Matthyssens (2002), Cort et al. (2007)
Unexpected opportunities	Merrilees et al. (1998), Freeman & Sandwell (2008)
Respond to client's demand	Vandermerwe & Chadwick (1989), Erramilli & Rao (1990),
To increase firm image	Koch (2001), Ling (2005)
To sustain firm growth	Olson & Wiedersheim-Paul (1978), Javalgi et al. (2003)
To increase firm profit	Cavusgil (1984), Leonidou et al. (2007)
To counter domestic business cycle	Rocha et al. (1990), Albaum et al. (2004)
To exploit firm resources	Winstead & Patterson (1998), Javalgi et al. (2003).
Home government support	Cavusgil & Yeoh (1994), UNCTAD (2006).
Competitor move	Terpstra & Yu (1988), Alavarez-Gil et al. (2003).
Firm-specific competitive advantages	
Quality of service	Ling (2005), Winch (2008)
Experienced & capable workforce	Schneider & Frey (1985), Erramilli and Rao, (1993)
Good client relationship with Malaysian businesses	Sharma & Johanson (1987), Cooper et al. (2000)
Innovative work processes & ideas	Bloodgood et al. (1996)
Domestic reputation	Dollinger et al. (1997), Ling (2005)
Good client relationship with multinationals in Malaysia	Sharma & Johanson (1987), Cooper et al. (2000)
Competitive fees	Orava & Wiklund (2004), Cort et al. (2007)
International reputation	Dollinger et al. (1997), Ling (2005)
International quality certification (e.g. ISO: 9001)	Withers & Ebrahimpour (2000)
Large financial capital	Cavusgil (1984), Gunham & Arditi (2005)
Home country-specific competitive advantages	
Mutual recognition of professional qualification	Zampetti (2000)
Malaysia's image as capable developing country	Javalgi et al. (2001)
Well developed & competitive industry	Sakakibara & Porter (2000)
Malaysia as a member country of Commonwealth, ASEAN, OIC, etc.	Plummer (2006)
National leadership backs internationalisation	Awil & Abdul-Aziz (2005)
Rapid economic development of Malaysia	Liu et al. (2005)
Multicultural/ multiracial society	Wilkinson & Cheng (1999), Steenkamp (2001)
Locational factors	
Political stability	Erramilli et al, (1997), Seung et al. (2005)
Law & order	Cavusgil and Zou (1994), Delios & Beamish (2004).
Market growth	Kirsch et al. (2000), Koch et al. (2001)
Financial freedom	Czinkota (2000)
Market size	Yoshida (1987), Kirsch et al. (2000)
Foreign direct investment laws & regulations	Erramilli (1992), Leonidou et al. (2007)
Professional qualifications rules & regulations	Winstead and Patterson (1998), Arnold (2005)
Air connection from Malaysia	Bruekner (2003)
Capital requirement	World Bank (2000), Czinkota (2000).
Foreign competition	Sharma (1988), Gorecki (1976)
Visa requirement	Bradley (2002)
Language & cultural similarities	Johanson and Vahle (1977)
Degree of business interaction with Malaysia	Håkansson & Snehota (1995)
Local competition	Sharma (1988), Sullivan & Bauerschmidt (1990)
Geographical distance from Malaysia	Leonidou et al. (2007), Ling and Chan (2008)
Methods of obtaining overseas work	

Invitation by client/other consultant in Malaysia needing services in host country	Vandermerwe and Chadwick (1989), Alavarez-Gil et el. (2003)
Invitation by client/ other consultant in host country needing services	Vandermerwe and Chadwick (1989), Alavarez-Gil et el. (2003)
Recommendation to client by affiliate/ sister company in other countries	Hinttu et al. (2004), Garg and Delios (2007)
Responding to international tenders/ international competition	Segal-Horn and Dean (2007),
Own marketing to clients in host country	Erramilli and Rao (1990), Alavarez-Gil et el. (2003)
Outsourcing by consultants in high cost country	Kee and Robbins (2003)
Invitation by client/ other consultant in third country needing the services in host country	Vandermerwe and Chadwick (1989), Alavarez-Gil et el. (2003)
Trade delegation	Leonidou et al. (2007)
Trade exhibition	Dekimpe et al. (1997), Leonidou et al. (2007)

RESEARCH METHOD

The sequential postal questionnaire survey-interviews approach was adopted to collect both quantitative and qualitative data so that the limitations of one method were compensated by the strengths of the other (Creswell, 2009). Quantitative methods are said to lack depth and understanding while qualitative methods are said to be anecdotal and hard to generalise. The mixed methods enable a fuller picture of the subject under investigation to be uncovered (Greene, 2008). Despite being called for by certain international business scholars, the mixed methods have been applied in strikingly limited studies (Nurmerinta-Peltomäki and Nummela, 2006).

The Professional Services Development Corporation (PSDC) was co-opted to increase industry participation in the study. PSDC was set up in 2002 by the federal government primarily to oversee and promote Malaysia's services exports. In turn, PDSC co-opted the Malaysian Institute of Architects (MIA), Institution of Surveyors Malaysia (ISM) and the Association of Consulting Engineers Malaysia (ACEM) to collaborate with the research.

The questionnaire was designed based on literature review, mainly on the services sector. Several variables were self-developed based on the researchers' limited knowledge on the subject matter. The 5-point Likert Scale was adopted for nearly all the questions. Iterative pilot test of the drafted questionnaire was conducted with representatives from MIA, ISM and ACEM respectively in the presence of one PSDC officer at PSDC's office in Kuala Lumpur. Minor changes to the format were made following their input. As no organisation, whether public or private, had compiled the list of consultancy firms which had international experience, the finalised questionnaires were sent out to all firms representing the three disciplines of architecture, civil engineering and quantity surveying. PSDC provided a letter endorsing the study. Repeated follow-up calls, emails and faxes were specifically made to non-responding firms which, from personal networks and secondary sources, were known to have gone overseas. Towards the end of the data collection exercise, PSDC came up with a list

of firms that had gone abroad. When combined with our own sources, the number of internationalised firms came to 138, out of which 47 returned the questionnaires (see Table 3). Non-parametric Friedman test was used to analyse the quantitative data. To compare the means between the three disciplines (i.e. architectural, civil engineering and quantity surveying) for the various variables, the non-parametric Kruskal-Wallis test was used. This test was suitable as the size of the sample was small and normality of distribution was absent. Besides, the sub-groups which were compared between each other were of unequal sizes. Following Dusuki and Abdullah (2007) and Pillania (2008), only the top and bottom three variables are discussed for the various response sets in the Discussion section

Table 3. The number of participating companies against the total that had internationalised.

Firm	Total approached (Internationalised and non-internationalised)	Total (internationalised)	Total respondents (internationalised)	Response rate
Architecture	941	54	15	28%
Civil engineering	979	62	19	31%
Quantity Surveying	278	22	13	59%
Total	**2,198**	**138**	**47**	**34%**

The next stage involved interviews with the respondents who indicated in the questionnaires their willingness to be interviewed. Interviews permit follow-up questions to be posed and further information to be collected by observation (Cooper and Schindler, 2003). Specifically, they allowed the 'how', 'why', 'when' and 'who' questions to be posed. Validation of questionnaire responses could also be conducted during the interviews. Prior to each interview, the respective firms' websites and news media articles were browsed through together with their returned questionnaires with the aim of preparing the semi-structured questions while at the same time avoiding redundant questions. In all 17 firms - seven architectural, six civil engineering and four quantity surveying firms - were interviewed. The interviews were tape-recorded and later transcribed, thus bringing the researcher 'close to the data' (Denscombe, 2003, p. 165).

FINDINGS

As shown in Table 4, the sampled firms came from diverse backgrounds in terms of number of employees, age and year they internationalised. In terms of legal status, the majority of the firms were private limited companies, although this fact had to do with limiting liability domestically rather than anything else.

Table 4. Basic profile of the sampled firms

Data	Percentage
Legal status of firm	
Individual proprietorship	20.0
Private limited company	73.3
Partnership	6.7
Number of employees	
< 11 persons	26.1
11-20 persons	30.4
21-30 persons	19.6
> 30 persons	23.9
Age of company	
< 10 years	29.8
10-19 years	29.7
20-29 years	25.5
30 years or more	14.9
Years of international experience	
< 5 years	47.5
Between 5 and 9 years	25.0
Between 10 and 14 years	12.5
Between 14 and 19	2.5
20 years and more	12.5

Source: Postal questionnaire survey

The largest architectural firm which participated in the study was 48-men strong, the largest civil engineering firm had 130 technical staff and its quantity surveying equivalent had 126 people. Incidentally, all three were among the largest in their respective disciplines in Malaysia. The smallest architectural firm had 10 technical persons, the smallest civil engineering firm and quantity surveying firms were 4-persons set-ups. The oldest participating civil engineering, architectural and quantity surveying firms were 47, 44 and 43 years old respectively. Again, they were also among the oldest in their respective disciplines in Malaysia as well. The youngest architectural and civil engineering firms were formed only a year before the survey whereas the youngest quantity surveying firm was established three years before the survey. The earliest architectural firm to venture overseas did so in 1968, its civil engineering equivalent in 1974 and the quantity surveying firm in 1975. There were many novices - just under half of the sampled firms had gone overseas from 2005 onwards. To sum it up, the sampled firms for all three disciplines varied in terms of number of employees, age and years of international experience.

The rest of this section presents the findings of the research. Only the top three and bottom three ranked variables are discussed because of space constraint.

Table 5. Countries the sampled firms serviced.

Economic status*	Country
Low income	Afghanistan, Bangladesh, Cambodia, Ghana, Kenya, Lao PDR, Myanmar, Nepal, Solomon Islands, Tanzania.
Lower middle income	China, India, Indonesia, Jordan, Maldives, Nigeria, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Sudan, Syria Arab Republic, Thailand, Vietnam, Yemen Rep.
Upper middle income	Algeria, Antigua & Barbuda, Cuba, Mauritius.
High income	Australia, Bahrain, Brunei, Canada, Hong Kong, Ireland, Oman, Qatar, Saudi Arabia, Singapore, United Arab Emirates, United Kingdom, United States.

*Note: * Categorisation according to the World Bank (2010).*

As Table 5 shows, the sampled firms had served countries near and far and of varying economic status, from the really impoverished such as Cambodia and Afghanistan to the affluent such as United States and United Arab Emirates. One large civil engineering firm which began venturing abroad since 1974 had gone to 20 countries. The servicing of high income countries of the United State and Canada begs explanation. Rather than establishing physical market presence in those countries and competing head-on with local firms, the few firms which had served those markets performed outsourced work for local firms based in North America.

Table 6. Motivation for internationalisation of all the consultant groups

Factor	N	Mean rank	Rank
Top management decision	47	7.58	1
Right time, right opportunities	47	7.03	2
Respond to client's demand	47	6.43	3
To improve firm image	46	6.07	4
To sustain firm growth	47	5.75	5
To increase firm profit	47	5.23	6
To counter domestic business cycle	46	5.18	7
To exploit firm resources	46	4.27	8
Home government support	46	3.91	9
Competitors' move	47	3.54	10
Chi-Square			
Asymp. Sig.			

Top management decision was the highest ranked motivation factor for internationalising among the sampled firms (see Table 6). A civil engineering firm with the longest international exposure was driven by its founder's vision to become the best in Asia. A director of an architectural firm said,

> "In the first place, you have to decide – do you want to or not. If you want, then you need to have a plan and start investing by establishing new contacts. If you don't want, of course you do not do these things. It is as simple as that."

The second highest motivation factor revealed that not all jobs obtained were planned. Unsolicited opportunities came even to those not ready, which then jump-

started their internationalisation trajectory. One architect director explained that the way to deal with unsolicited international jobs was to be constantly ready to work abroad. One quantity surveyor principal explained that a background check on the firm would have preceded the unsolicited invitation by the clients or their consultants. And so, while the invitation was unexpected for the recipient firm, it was well thought out by the party making the invitation. Responding to client's demand was the third highest ranked motivation. Several interviewees pointed out that to maintain client patronage, firms were compelled to follow their established clients abroad, reluctant they may be. The third lowest motivation factor was to exploit firm resources. The managing director of a large civil engineering firm rhetorically asked in connection with the more than 60 technical people his firm employed, "What am I going to do with them otherwise?" However it is apparent from the relatively low score given that the issue of surplus firm resources did not come into play in the internationalisation of the majority of sampled firms. The second lowest motivation factor was home government support. There was broad consensus among the interviewees that the Malaysian government was not doing enough for the export promotion of business services. They complained most of all about the difficulty in getting financial assistance from the EXIM Bank. Paperwork and bureaucracy were the other problems associated with government assistance. The lowest motivation factor was competitors' move. One architect director commented that his vision, not his competitors' actions, drove him to venture overseas. Another interviewee pointed out that if at all, it was the Malaysian international contractors rather than compatriot international consultants that provided the impetus to go abroad.

Table 7. Comparison of results between the various consultant groups regarding motivation for internationalisation

Factor	Arch	Civil Eng	QS	X^2
Top management decision	23.10	24.76	23.92	0.228
Right time, right opportunities	22.50	24.24	25.38	0.438
Respond to client's demand	23.47	23.87	24.81	0.084
Improve firm image	20.57	25.55	23.65	1.289
Sustain firm growth	20.30	28.32	21.96	3.772
Increase firm profit	19.00	28.32	23.46	4.393
Counter domestic business cycle	22.50	25.16	22.15	0.573
Exploit firm resources	21.71	24.11	24.54	0.406
Home government support	21.43	26.39	21.50	1.628
Competitors' move	22.73	28.97	18.19	5.246*

Notes: *** indicates p-value < 0.01, ** indicates that p=value < 0.05, * indicates that p-value < 0.1

When comparing the responses between the various sub-groups using the Kruskal Wallis test, only one difference stood out, and that was competitors' moves which incidentally was the lowest ranked variable indicated in Table 7. The sampled civil engineering firms were more driven by competitors' actions in comparison to firms representing the other two disciplines.

Table 8. Firm-specific competitive advantages of all the consultant groups

Factor	N	Mean Rank	Rank
Quality of service	47	7.30	1
Experienced and capable workforce	47	6.77	2
Good client relationship with Malaysian businesses	47	6.22	3
Innovative work processes and ideas	47	5.91	4
Domestic reputation	47	5.72	5
Good client relationship with multinationals in Malaysia	47	5.48	6
Competitive fees	47	4.75	7
International reputation	47	4.70	8
International quality certification (e.g. ISO: 9001)	47	4.25	9
Large financial capital	46	3.90	10
Chi-Square	79.092		
Asymp. Sig.	p=0.000, p<0.01		

Quality of service was the highest ranked firm-specific competitive advantage (see Table 8). All the interviewees concurred that foreign clients' expectation of service quality was high, much higher than their Malaysian counterparts. Tied to quality of service was quality of workforce. One quantity surveyor managing director said that if a firm does not have experienced and capable workforce, it cannot export its service. "It is as simple as that," he said. His firm had to forego a large project in Saudi Arabia because none of the Malaysian staff was willing to be posted there. Competent people are not cheap. And they are constantly being poached by rival firms, added a few interviewees. The third highest ranked firm-specific competitive advantage was good client relationship with Malaysian businesses. Only after having forged good relationship would clients take their consultants overseas for their projects. International reputation was the third lowest ranked factor, alluding to the still-limited exposure the sampled firms in general had accumulated. The lack of international reputation meant that it took a lot of hard selling to convince foreign clients and other parties to engage them, explained one interviewee. International quality certification was the second lowest ranked firm-specific competitive advantage. Instead of securing such certification, two architectural firms preferred to develop their own quality management systems. Actual quality of service (which was ranked highest) was of much greater concern than quality certification by a third party. Large financial capital was the lowest ranked factor. The consensus among the interviewees was that while initial start-up of offices in foreign countries was costly, it was not exorbitant. None of the sampled firms had to resort to bank loans to finance local presence in host countries. In fact venturing overseas could be almost costless - when venturing abroad on the back of clients, the consultants' travelling and lodging expenses were initially covered by the clients before later deducted from their fees. Performing outsourcing work for foreign consultants was another almost costless exercise.

Table 9. Comparison of results between the various consultant groups regarding firm-specific competitive advantages

Factor	Arch	Civil Eng	QS	X^2
Quality of service	21.07	26.95	23.08	2.666
Experienced and capable workforce	21.77	25.08	25.00	0.792
Good client relationship with Malaysian businesses	22.50	24.18	25.46	0.413
Innovative work processes and ideas	22.50	26.03	22.77	0.829
Domestic reputation	20.73	26.32	24.38	1.644
Good client relationship with multinationals in Malaysia	24.00	22.55	26.12	0.604
Competitive fees	21.23	26.11	24.12	1.179
International reputation	18.30	28.11	24.58	4.727*
International quality certification (e.g. ISO: 9001)	19.23	29.08	22.08	5.190*
Large financial capital	22.50	26.55	20.12	2.098

Notes: *** indicates p-value < 0.01, ** indicates that p=value < 0.05, * indicates that p-value < 0.1

Kruskal-Wallis test revealed variation for two variables - international reputation and international quality certification (see Table 9). For both factors, the civil engineering firms gave higher scores compared to the architectural firms which gave comparably the lowest scores. It is noteworthy that these two variables were ranked relatively low in Table 8.

Table 10. Home country-specific competitive advantages of the surveyed firms.

Factor	N	Mean Rank	Rank
Mutual recognition of professional qualification	47	5.20	1
Malaysia's image as capable developing country	47	4.73	2
Well developed and competitive industry	47	4.21	3
Malaysia as a member country of Commonwealth, ASEAN, OIC, etc.	47	3.78	4
National leadership backs internationalisation	47	3.62	5
Rapid economic development of Malaysia	47	3.59	6
Multicultural/ multiracial society	47	2.87	7
Chi-Square	55.903		
Asymp. Sig.	P=0.00, p<0.01		

Of the home country-specific competitive advantages, mutual recognition of professional qualifications ranked the highest (see Table 10). While countries may enter into Mutual Recognition Agreements (MRA) to recognise each other's professional qualifications, the interviewees explained that informal recognition by professionals in host and third countries had a greater impact than formal recognition. According to the interviewees, Malaysian professionals were known for being competent and yet accommodating. The second highest variable was Malaysia's image as a capable developing country. Malaysia's image as epitomised by the iconic Twins Towers and the North-South Highway had helped its construction-related consultants to secure work abroad. The third highest ranked variable was well developed and competitive industry. All the interviewees concurred that competition for private sector work in Malaysia was keen. To survive, firms had to provide the best services to private sector clients at razor-thin profit margins. "There is always someone willing to do the job,

especially newcomers," noted one interviewee. As for the third lowest home country-specific competitive advantage, the interviewees concurred that ex-prime minister Mahathir Mohamed was the best salesman Malaysia ever had. While there were people overseas who still remembered him, his influence was waning. His successors have not been able to match his salesmanship. The nation's rapid economic development was the second lowest factor. Despite having developed rapidly, the questionnaire respondents did not regard it as having contributed much to their internationalisation compared to other factors. Malaysia's multicultural or multiracial society was ranked the lowest. The general perception was that this factor did not facilitate the consultants to secure work overseas. One interviewee cited that western consultants were held in higher regard in the Middle East despite being of dissimilar religion with the locals.

Table 11. Comparison of responses between the various consultant groups regarding home country-specific competitive advantages

Factor	Arch	Civil Eng	QS	X^2
Mutual recognition of professional qualification	22.17	26.89	21.88	1.617
Malaysia's image as capable developing country	20.33	28.11	22.23	3.351
Well developed and competitive industry	23.60	25.82	21.81	0.752
Malaysia as a member country of Commonwealth, ASEAN, OIC etc.	19.43	30.18	20.23	7.031**
National leadership backs internationalisation	25.07	25.55	20.50	1.281
Rapid economic development of Malaysia	23.10	26.95	20.73	1.862
Multicultural/ multiracial society	23.23	26.45	21.31	1.224

Notes: *** indicates p-value < 0.01, ** indicates that p=value < 0.05, * indicates that p-value < 0.1

The Kruskal-Wallis test indicated statistically that between the three consultant groups, there was significant variation in the responses for only one of the variables, i.e. Malaysia as a member of economic groupings with the sampled civil engineering firms giving comparably higher scores compared to architectural and quantity surveying firms (see Table 11).

Table 12. Location factors considered before entering foreign markets.

Factor	N	Mean Rank	Rank
Political stability	47	11.20	1
Law and order	47	10.77	2
Market growth	47	9.80	3
Financial freedom	46	9.17	4
Market size	47	9.10	5
Foreign direct investment laws & regulations	47	8.90	6
Professional qualifications rules & regulations	47	8.66	7
Air connection from Malaysia	47	7.60	8
Capital requirement	47	7.13	9
Foreign competition	47	7.04	10
Visa requirement	47	6.86	11
Language and cultural similarities	47	6.65	12
Degree of business interaction with Malaysia	47	6.00	13
Local competition	47	5.59	14
Geographical distance from Malaysia	47	5.52	15

Political stability was the highest ranked location factor (see Table 12), which was understandable since many of the countries the sampled firms ventured into were developing countries (see Table 4). Closely related to political stability was law and order which was ranked second highest. Personal safety of their employees and themselves was a deep concern of top management. One sole principal decided against working in Algeria out of grave safety concern. Growing markets create the space for new entrants to secure work. This variable was ranked third highest, which incidentally was ranked higher than market size. Degree of business interaction of host parties with Malaysia was the third lowest factor. One architect firm secured work in China on the basis that the Chinese client was impressed with a shopping mall in Kuala Lumpur it had designed. Such instances however were uncommon. In many of the countries the sampled firms ventured into, local competition posed minimal threat. Geographical distance from Malaysia was the lowest ranked location factor. This was also evident from Table 4 which shows the sampled firms venturing near and far.

Table 13. Comparison of responses between the various consultant groups regarding locational factors.

Factor	Arch	Civil Eng	QS	X^2
Political stability	23.80	26.95	19.92	2.828
Law and order	21.93	25.37	24.38	0.772
Market growth	25.40	23.63	22.92	0.307
Financial freedom	20.90	26.31	22.62	1.626
Market size	23.13	24.71	23.96	0.129
Foreign direct investment laws & regulations	19.70	26.55	25.23	2.522
Professional qualification rules & regulations	18.00	28.08	24.96	5.223*
Air connection from Malaysia	24.17	19.92	29.77	4.589
Capital requirement	18.10	27.76	25.31	4.797*
Foreign competition	22.40	25.63	23.46	0.540
Visa requirement	23.60	24.50	23.73	0.049
Language and cultural similarities	21.73	24.16	26.38	0.867
Degree of business interaction with Malaysia	20.60	27.79	22.38	2.860
Local competition	19.73	26.24	25.65	2.314
Geographical distance from Malaysia	23.60	21.53	28.08	1.991

Notes: *** indicates p-value < 0.01, ** indicates that p=value < 0.05, * indicates that p-value < 0.1

When comparing between the three consultant groups (see Table 13), the Kruskal-Wallis test indicated that there was significant variation in the responses given for only two variables: professional qualification rules and regulations and capital requirement. The sampled architectural firms gave comparably lower scores compared to the civil engineering and quantity surveying firms for both of them. The three consultant groups however concurred with the top and bottom three variables.

Table 14. Methods of obtaining overseas work

Factor	N	Mean rank	Rank
Invitation by client/other consultant in Malaysia needing services in host country	45	7.29	1
Invitation by client/ other consultant in host country needing services	45	6.01	2
Recommendation to client by affiliate/ sister company in other countries	45	5.75	3
Responding to international tenders/ international competition	45	5.18	4
Own marketing to clients in host country	45	5.18	4
Outsourcing by consultants in high cost country	41	4.35	6
Invitation by client/ other consultant in third country needing the services in host country	44	4.23	7
Trade delegation	45	3.68	8
Trade exhibition	45	3.35	9

The top three methods of obtaining work overseas highlight the importance of networks (Malaysian clients or consultants, host clients or consultants and recommendations to clients by affiliate or sister companies) in securing overseas work (see Table 14). The third lowest factor however indicates the weaker links with third country parties in securing work in host countries, again a reflection of their more recent international foray. The sampled firms benefited the least from trade delegations and trade exhibitions. A few interviewees indicated that they had never been invited to participate in trade delegations whereas they knew of others who were. Besides, the chances of securing work from trade delegations were slim. At best, they provided the opportunity for delegates to get first-hand knowledge of the countries they visited, said one internationally seasoned associate director. Trade exhibitions were more suited to architectural firms. The high cost of preparing exhibitions however was off-putting for one interviewee.

Table 15. Comparison of responses between the various consultant groups regarding methods of obtaining overseas work

Factor	Arch	Civil Eng	QS	X^2
Invitation by client/other consultant in Malaysia needing services in host country	22.19	20.08	28.08	3.187
Invitation by client/ other consultant in host country needing services	20.42	26.79	18.15	4.212
Recommendation to client by affiliate/ sister company in other countries	26.77	21.61	21.27	1.622
Responding to international tenders/ international competition	28.69	23.11	17.15	5.442*
Own marketing to clients in host country	25.96	25.16	16.88	4.223
Outsourcing by consultants in high cost country	21.17	22.28	19.27	0.507
Invitation by client/ other consultant in third country needing the services in host country	11.13	31.68	19.58	22.163***
Trade delegation	26.31	25.68	15.77	6.341**
Trade exhibition	27.73	23.71	17.23	5.021*

Notes: *** indicates p-value < 0.01, ** indicates that p=value < 0.05, * indicates that p-value < 0.1

The Kruskal-Wallis test highlighted the differences in the responses given by the various subgroups for response for international tenders, trade delegations, trade exhibitions, and invitations by clients or consultants in third countries with architectural firms recording the highest scores for the first three variables and civil engineering firms the highest for the last variable (see Table 15). It should be pointed out despite these differences, there was concurrence among the three sub-groups for the top three ranked variables.

DISCUSSIONS

The top three motivations for internationalisation were top management decision, right time, right opportunities and responding to client's demand, thereby supporting the Axinn and Matthyssens (2002), Freeman and Sandwell (2008) and Erramilli and Rao (1990) respectively. The bottom three motivations for internationalisation were exploit firm resources, home government support and competitors' move. These three findings provided weak support to Winstead and Patterson (1998), Cavusgil and Yeoh (1994) and Tepstra and Yu (1988) respectively. Generally there was concurrence in responses given by the three sub-groups for the tested motivations variables.

The top three firm-specific competitive advantages were quality of service, experienced and capable workforce, and good client relationship with Malaysian businesses, lending credence to Ling (2005), Schneider and Frey (1985) and Cooper et al. (2000). The research however weakly supported Cort et al. (2007), Erel and Ghosh (1997) and Gunham and Arditi (2005) following competitive fees, international quality certification and large financial capital being located at the bottom three of the ranked list. Generally also, there was concurrence in responses given by the three sub-groups for the tested firm-specific competitive advantages variables.

As for home country-specific competitive advantages, the top three ranked variables were mutual recognition of professional qualification, Malaysia's image as a capable developing country and well developed and competitive industry, thereby supporting past studies by Sakakibara and Porter (2000), Zampetti (2000) and Javalgi et al. (2001). Whereas the bottom three variables were national leadership backs internationalisation, rapid economic development and multicultural or multiracial society, contrary to what was found by Awil and Abdul-Aziz (2005), Liu et al. (2005) and Wilkinson and Cheng (1999) in their respective studies. Overall all three subgroups showed concurrence in the responses they gave to the tested home country-specific competitive advantages variables, in particular the top three and bottom three ranked variables.

Political stability, law and order, and market growth were the top three locational factors, lending credence to Seung et al. (2005), Cavusgil and Zou (1994) and Koch et al. (2001) respectively. Degree of business interaction with Malaysia, local competition and geographical distance were the bottom three locational factors,

thus weakly supporting Håkansson and Snehota (1995), Sullivan and Bauerschmidt (1990) and Leonidou et al. (2007) respectively. There was broad consensus between the subgroups in the responses they gave to the tested locational factors variables, especially the top three and bottom three variables.

Invitations by Malaysian and host clients and consultants needing the services of the responding firms in host countries were the top two methods of obtaining overseas work, which cohere with Vandermerwe and Chadwick (1989). Recommendations to clients by affiliate or sister companies in other countries was the third highest ranked variable, supporting Hinttu et al. (2004). Invitation by clients or consultants in third countries was the third lowest ranked variable, indicating that while networks with certain parties can bring business windfall, with others, the impact is less so. Trade delegation and trade exhibition were the ranked the last two, hence not providing support to Dekimpe et al. (1997) and Leonidou et al. (2007) respectively. It is on the aspect of methods of obtaining overseas work that there was the greatest divergence in scores given by the three sub-groups. Having said that, there was statistical concurrence on the responses all three sub-groups gave to the top three ranked variables.

CONCLUSION

The firms that had gone international were of varying ages, sizes and experiences. They have together served countries of varying economic status. Their prime motivation for internationalisation was top management decision. They were least influenced by their competitors' internationalisation efforts. Quality of service was their strongest firm-specific competitive asset whereas mutual recognition of professional qualification was their strongest home country-specific competitive strength. Political stability was foremost in their minds when evaluating host markets. Geographical distance was the least of their location concerns. Networks particularly with compatriot clients and consultants provided the most important source of overseas work. The Kruskal-Wallis test showed that broadly there was concurrence in the response given by all three sub-groups, especially for the top three ranked variables of the various data sets, even the bottom three ranked variable in nearly all the data sets.

Based on the broad consensus between all three-sub-groups, lessons can be drawn from the study for construction-related consultants located in other developing countries wishing to internationalise. Internationalisation ultimately rests with top management, whether they may be able to rationalise it or otherwise. Be prepared for unsolicited opportunities. They must give attention to service quality, which can only be derived from quality workforce. The service quality must match what foreign, not local, clients are accustomed to. Human resource management, in particular attracting and retaining technically sound personnel, is therefore key in succeeding abroad. Only with quality service can they expect to nurture good relationships with clients. Informal recognition by fellow consultants in host countries suffice; there is

no need to wait for mutual recognitions agreements to be signed between the home and host countries. The firms are more likely to make inroads in other developing countries than advanced economies. Personal safety must take precedence above all other location factors, even market opportunities. They however must be prepared to serve geographically distant national markets. Strong business networks provide an important source of work. For that reason, forging and maintaining a good relation with clients at all times is good investment. Trade delegations and trade exhibitions are costly but offer little likelihood for generating business opportunities.

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TRANSITION FROM ISO 9000 TO TQM: RECOMMENDATIONS FOR THE NIGERIAN CONSTRUCTION INDUSTRY

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Abstract
The purpose of this study is to investigate ISO 9000 Quality Management System (QMS) in Nigeria to gauge the readiness for Total Quality Management (TQM). Through reviews of the relevant literatures, this study identified possible challenges toward ISO 9000 standards and TQM implementation in Nigeria. Nigeria's business environment, myths disguised in the form of challenges and warped understandings have prevented the implementation of ISO 9000 standards while short-termism and complacency have also prevented transcending from ISO 9000 standards to TQM. This study is limited to ISO 9000 QMS and TQM as two possible management tools for Quality Management (QM) in Nigeria; future researches can investigate other forms of QM in Nigeria. Practical implications of the study include improved understanding of the ISO 9000 standards and TQM as well as their interdependencies that could serve as the basis for improved awareness on quality and QM in the Nigerian context. Against the background of the unique challenges in Nigeria's construction industry, short-, medium- and long-term plans as well as concerted efforts to boost ISO 9000 standards and TQM implementations, with a proposed model, are presented in this study.

Keywords: *Implementation; ISO 9000; Nigeria; Quality; TQM*

INTRODUCTION

Throughout history, construction had been an important hallmark of civilization (Cokinos, 2009: 9). The construction industry is one of the world's biggest industries and is estimated to account for about 13.4% and 14.6% of world output and gross domestic product respectively by 2020 (Binder Dijker Otte LLP (BDO), 2010). Conversely, as the industry grows and evolves, it has become increasingly more complex and fragmented so much so that it has gained the infamous tripartite image of being "dirty", "difficult" and "dangerous" (International Labour Organization, 2001). Hence, the industry has been criticized for its poor performance and productivity, especially, in relation to other industries e.g. manufacturing during the past decades (Hoonakker *et al.*, 2010: 953). In the Eleventh Annual Survey of Owners undertaken by FMI (www.fminet.com) and the Construction Management Association of America (CMAA), complaints and disruptions due to decline in quality of both documentation and services were widely reported (FMI and CMAA, 2010: 5). Out of the more than 300 owners that responded, reductions in the quality of: design documents, construction drawings, construction management services, and construction execution were reported by 34%, 33%, 16% and 18% of the respondents respectively. With these responses and also as construed by Mahmood *et al.* (2006: 1), it is not only the final product that is subject to criticisms, but also the processes, people, and materials among others. Thus, the construction industry has turned to the manufacturing sector for successful concepts such as Total Quality Management (TQM) (Hoonakker *et al.*, 2010: 953) as an initiative to solve quality problems and to meet the needs of the customer first time, all the time.

Apart from TQM, Quality Management System (QMS) abounds and of which the International Organization for Standardization's (ISO) 9000 standards for QMS, specifically, the ISO 9001: 2008 (a latter version of the ISO 9001: 2000) continued to garner widespread and global adoption (ISO, 2011). This is attributable to the capability of the ISO 9000 standards to provide the necessary impetuses toward the ultimate adoption of TQM as discussed in a later Section of this present study. ISO's yearly global survey of certified companies commenced in 1993, which saw Nigeria making its debut in 1995 with just one certified company behind South Africa and Egypt at 1,369 and 16 respectively, having made debuts in 1993 and 1994 respectively (ISO, 2000: 11). Between 2008-2009, Nigeria recorded a 31.9% ISO 9001 growth to occupy the 20th position in the top 30 for that period. Sampaio (2011: 12) suggested that generally for the top 30, this could be attributable to the high number of Small and Medium Enterprises (SMEs) being certified. Nevertheless, Nigeria with a total of 163 certifications still lagged behind South Africa and Egypt at 3,792 and 1,944 respectively as at end 2008 based on ISO's (2009a: 17) report. This is a concern considering Nigeria's sheer population of about 162.5 million (UNFPA, 2011: 119) making it the most populous country and biggest market in Africa. Questions arise ranging from the disposition of the Nigerian construction industry towards quality, its familiarity with the ISO 9000 implementation and benefits as well as its readiness to embrace TQM. The meteoric rise of the Chinese companies in infrastructure development projects in Nigeria vis-à-vis mounting allegations over poor quality of services have also seen some industry practitioners (Utomi, 2008: 47; Deng, 2011) suggesting that such practices also bear on the footing that the Nigerian market has nurtured it. Hence, it is timely that a study be undertaken to investigate Quality Management (QM) implementation in Nigeria.

The aim/purpose of this study is to investigate the adoption of ISO 9000 QMS in Nigeria to gauge the readiness for TQM. The specific objectives include to: (1) investigate ISO 9000 standards and certification in Nigeria, (2) investigate the possible challenges against the implementation of ISO 9000 and TQM, and (3) investigate the current state of TQM in Nigeria to identify the gaps with ISO 9000. The primary research methodology adopted is literature review.

LITERATURE REVIEW ON THE NIGERIAN CONSTRUCTION INDUSTRY

Overview of Nigeria's construction industry

Nigeria's construction industry continued to occupy an important position in its economic growth (Mansfield *et al.,* 1994: 254; Aibinu and Jagboro, 2002: 593). Nigeria's fastest urbanization in sub-Saharan Africa (Oluwakiyesi, 2011: 8) and vast potentials makes it a major target for aspiring foreign players (Momoh, 2011). Ernst & Young (2011: 45) identified South Africa, Nigeria and Egypt as the three large economies in Africa. Nigeria's construction industry was modeled after the British system with influences from Italy, Germany, France (Mansfield *et al.,* 1994: 255) and ongoing changes (Aibinu and Odeyinka, 2006: 676). The industry is plagued with poor technical and managerial skills of contractors (Ofori, 1991: 35) cum the absence of a central coordinating body (Ofori, 1994: 48) as a developing market; project delays and total abandonment (Aibinu and Jagboro, 2002: 593-4); inaccessibility to credit facilities (Nigeria Business, 2006), high fragmentation in that no national agency

(Aibinu and Odeyinka, 2006: 676); over dependence on foreign inputs (Aniekwu, 1995: 450) to continued dominance by foreign construction firms (Oluwakiyesi, 2011: 12). Project management is one of the expertise to deal with low cost housing in Nigeria (Oladapo, 2001: 11); conversely, it remained at infancy (Odusami *et al*., 2003). Often, Nigerian clients favor minimizing cost at the expense of the performance and quality of buildings (Oyedele and Tham, 2007: 2097). Currently, Nigeria ranks 133 among 183 economies in the ease of doing business (World Bank and IFC, 2012: 6).

Quality initiatives in Nigeria

The Standards Organization of Nigeria (SON) (www.sononline.org) is the body that establishes and monitors industry quality standards in Nigeria (United Nations, 2002: 6). SON is a full-fledged statutory agency established by Nigeria's Act No. 56 of 1971 (SON, 2011: 2). The ISO also recognizes SON as a member body serving as the only national body most representative of standardization in a country (ISO, 2012a). In Nigeria, SON has been involved in ensuring the formulation of the necessary standards to define the quality parameters for all materials (Adeyemi, 2010). SON operates through two main instruments namely: SON Conformity Assessment Programme (SONCAP) for imports and the Mandatory Conformity Assessment Programme (MANCAP) for exports (SON, 2011: 3-4). SON's sustained training programme for industries and SON staff on the Nigerian Industrial Standards (NIS) ISO 9000 QMS received the highest number of participations as at January 2011 compared to other standards (SON, 2011: 5). Nevertheless, the considerably wide gap between Nigeria and South Africa and Egypt as shown in Figure 1, calls for deliberate and concerted efforts to raise quality standards in the supply chain. Odusami *et al.* (2010) has also flagged the need for the Nigerian business environment to raise quality standards through regulations and requirements as impetuses for specific quality policies and practices to be incorporated in construction organizations' QMS. There is no official information on the number of construction companies in Nigeria that are ISO 9001 certified. However, from ISO's (2009a: 17) report, a total of 163 companies (construction inclusive) were certified in Nigeria as at end 2008, which was the highest since 1995 as also presented in Figure 1. SON, apparently realizing the dearth in ISO 9001 certification in Nigeria, especially among the SMEs that formed about 80% of the country's total production capacity, officially commenced a pilot program to increase the number of ISO 9001 certified SMEs to 42 from the current 10, and ultimately 250 by the end of the program (Osagie, 2012).

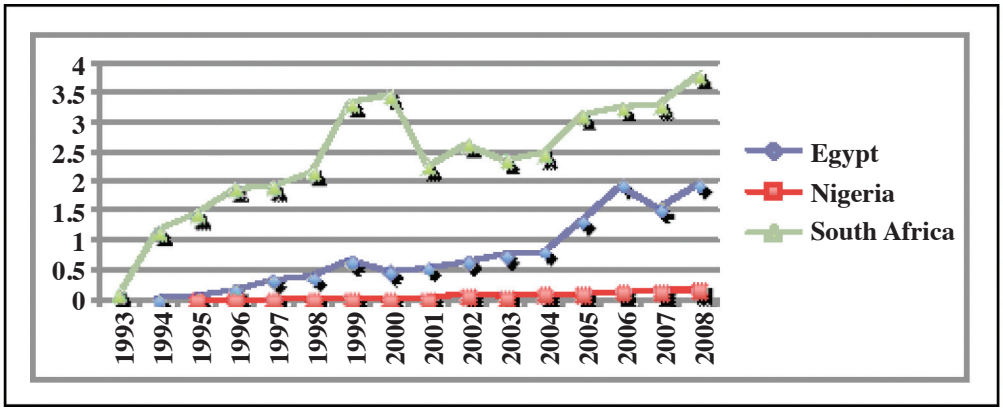

Figure 1. ISO 9001: 2000 and 2008 certifications in Egypt, Nigeria and South Africa (Scale: 1: 1000). Source: Adapted from ISO Surveys 1993-2008.

LITERATURE REVIEW ON QUALITY

Quality and quality management

Crosby (1979), Deming (1986) and Juran (1988) defined quality as "conformance to requirements", "by the agent i.e. customer", and "fitness for purpose" respectively. Quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy implied or stated needs (ANSI/ASQC, 1987). Quality is all those features of a product or a service, which are required by the customer, and QM is what an organization does to ensure that its products conform to the customer's requirements (ISO, 2000). QM refers to the process of identifying and administering the activities needed to achieve the quality objectives of an organization (Stupak and Leitner, 2001: 2). Hence, effective QM is premised on the techniques of perceiving and interpreting quality i.e. a service that is also free of deficiencies (ASQ, 2012).

Quality Management Systems (QMS) and the ISO 9001

The ISO was founded in 1946 to develop standards that would facilitate international trade, with organizations registering to one of the three contractual models ISO 9001, 9002, and 9003 until the inception of the 2000 standards that they need only register to the more comprehensive ISO 9001 (Johnson, 2000: 6; Kemp, 2006: 195; Goetsch and Davis, 2012: 233). ISO 9001: 2000 raised the bar from a quality assurance system of minimal compliance to a QMS that recognizes an organization's commitment to quality and to the customer (Taormina and Brewer, 2002: 2). ISO 9001 (2000 and its latter 2008 version) provides the requirements for QMS, which is now firmly established as the globally implemented standard for providing assurance about the ability to satisfy quality requirements and to enhance customer satisfaction in supplier-customer relationships (ISO, 2009b).

Quality Management (QM) principles

The ISO 9000 QMS has set forth eight QM principles, to facilitate the achievement of quality objectives (Johnson, 2000: 33), to be used by top management to improve performance (Taormina and Brewer, 2002: 59), and to represent the total quality philosophy for an effective and conforming QMS (Goetsch and Davis, 2012: 233), as follow: (1) *Customer focus*, (2) *Leadership*, (3) *People involvement*, (4) *Process approach*, (5) *System approach to management*, (6) *Continual improvement*, (7) *Factual approach to decision making*, and (8) *Mutually beneficial supplier relationships*. The eight QM principles are suggestive of their respective own definitions; moreover, ISO (2012b) provides a holistic view of the eight QM principles.

ISO 9000 implementation

Simply, ISO 9000 standards require an organization to say, do, and prove what it is doing to ensure quality (Besterfield *et al*., 1995: 219). It is a good, hardheaded common business sense in codified, verifiable, and easily adapted form (Johnson, 2000: 7). The verification presupposes that an organization can register to ISO 9000 and the *registration* or *certification*,

by an accredited third-party registration body or *registrar*, provides benefits of a QMS as well as significant strategic advantages (Johnson, 2000: 7). Nevertheless, the certification is voluntary and undertaken by various registrars including public and private as well as early adopters of ISO 9000 (Guler *et al*., 2002: 209). Conversely, without registration, credibility becomes an issue and the absence of a registrar to observe conformance in order to maintain an ISO 9000 certificate may also nurture a lack of impetus on quality and significantly affect an organization's market position (Goetsch and Davis, 2012: 235).

Benefits of ISO 9000 implementation

ISO 9000 standards have become universally accepted arising from worldwide emphasis on quality and economic competitiveness (Besterfield *et al.*, 1995: 217). The advantages of the certification include: better QM practices and quality results (Rao *et al.*, 1997); access to new markets, competitive advantage, potential customer audit reduction, and improved bottom line (Johnson, 2000: 23-26); reduction in product liability, and a form of launching pad for continuous improvement (Taormina and Brewer, 2002: 18); a key organizational practice helping companies worldwide to establish rationalized production process (Guler *et al*., 2002: 208); a way to fulfilling customer and applicable regulatory requirements (ISO, 2005: v); a cheaper QMS package than reinventing the wheel as well as a quicker way to expert opinions on problems in time to fix them (Kemp, 2006: 192); corporate survival, sales growth, and improved worker safety (Levine and Toffel, 2010) for improved competitiveness (Goetsch and Davis, 2012: 236). Similarly, for the construction industry, Bubshait and Al-Altiq (1999: 42) summarized that the benefits vary including: a means to improving the overall quality of operations, the requirements of customers to be complied with, a necessary response to competition, a way to reduce costs, a means to improve the flow activities and coordination in the organization, a strategy to have better sales through an improved image, and a way to maintain competitive edge in the industry.

Challenges of ISO 9000 implementation

The myths disguised in the form of challenges for 1SO 9000 implementation include that it is: a mandatory system to doing business overseas, a paperwork nightmare, an inspection to sort out defects, and a claim to guarantee quality outside an organization (Johnson, 2000: 4). The warped understanding made Taormina and Brewer (2002: 12) delineate that it is: evolution not revolution, a culture not a program, structure not control, and boundaries not anarchy. Other drawbacks have it as: costly and time consuming thus a major deterrent to SMEs (Dissanayaka *et al.*, 2001: 30); correlated with increased work pressure leading to cumulative trauma disorders (Brenner *et al*., 2004); unhealthy focus primarily to satisfy customers' requirements at the detriment of company's business benefits (Hong and Phitayawejwiwat, 2005: 5); having swaying credibility to the point that Goetsch and Davis (2012: 239) submitted that once that cannot be assured, ISO 9000 would be made redundant. Bubshait and Al-Altiq (1999: 42) construed the special features in the construction industry as limiting the implementation of the ISO 9000 standard, some of which includes: usually a unique collection of people, equipment, and materials at a unique location under unique weather conditions; prevalent practice of separate contracts for design and construction; a set-up involving multi-parties of whom efforts are required to achieve quality construction; a

predominately transient workforce, subject to high turnover, which affects long-term plans, and so on.

LITERATURE REVIEW ON TQM

TQM and relationships with ISO 9000

TQM is for the most part common sense and by analysing the three words *total*, *quality*, and *management* to culminate into "the art of managing the whole to achieve excellence" (Besterfield *et al.*, 1995: 1). A TQM organization is one that has the capacity to change itself to adapt to the environment it operates (Mead and Andrews, 2009: 263). TQM is sets of systematic activities carried out by the entire organization to effectively and efficiently achieve the organization's objectives so as to provide products and services with a level of quality that satisfies customers, at the appropriate time and price (Deming Prize Committee, 2012: 2). Long implicit in the ISO 9000 QMS is the total quality concept, which hitherto remained fraught with short-termism from survival as more pressing needs (Love and Holt, 2000), complacency with the ISO 9000 certification (Zairi and Baidoun, 2003: 7) due in part to the shun by the majority of the SMEs (Yusof and Aspinwall, 2000: 234), not wanting to subject employees to the cultural shock of TQM implementation (Low and Teo 2004: 10) and organizations' difficulties with measuring TQM (Arumugam *et al*., 2009: 49).

Differences between TQM and ISO 9000

In terms of the focus of implementation and monitoring, TQM and ISO 9000 differ. An organization's focus on the ISO 9000 standards is on fulfilling the technical requirements, which is only one aspect of TQM (Low, 1998: 34). ISO 9000 registration would be easy to get for firms that already have significant quality systems in place and relatively easy to keep (Johnson, 2000: 7). However, ISO 9000's greater emphasis on auditing presupposes less effort to influence workers' commitments to quality (Kemp, 2006: 199-200) as with TQM. Goetsch and Davis (2012: 237) suggested that the key difference of TQM from ISO 9000 is in the degree to which the total organization is involved. Nevertheless, (1) ISO 9000 and TQM are not interchangeable, (2) ISO 9000 is compatible with, and can be viewed as TQM, (3) ISO 9000 is frequently implemented in a non-TQM environment, (4) ISO 9000 can improve operations in a traditional environment, (5) ISO 9000 may be redundant in a mature TQM environment, and (6) ISO 9000 and TQM are not competition (Goetsch and Davis, 2012: 236-239).

Transcending from ISO 9000 to TQM

ISO 9000 QMS is an excellent first step towards TQM (Besterfield *et al.*, 1995: 241; Kemp, 2006: 199), it has much in common with other quality schemes, such as W. Edwards Deming's 14 points, TQM, and the Malcolm Baldrige National Quality Award (MBNQA) criteria (Johnson, 2000: 7) and together with TQM continued to be the two pillars to improve and manage quality (Heras *et al*., 2002: 72). ISO 9000 could certainly be adapted to a TQM organization at a reasonable cost (Kemp, 2006: 200) and if it is in place, firms should implement a TQM system (Abdul-Rahman, 2008: 8). ISO 9000 standard was rewritten in 2000

to incorporate the TQM concepts and it remained that the two principal quality initiatives at work in the world today are ISO 9000 and TQM (Goetsch and Davis, 2012: 236). Importantly, human behavioural attributes should be considered in implementing and maintaining a quality system to deliver total quality service (Low, 1998: 44) as TQM has evolved into incorporating the hard and soft aspects of QM (Arumugam *et al*., 2009: 47).

Cases of successful ISO 9000 contribution towards TQM

The following studies on ISO 9000 certified companies support that ISO 9000 implementation is a logical and practical step towards TQM journey: (1) Gotzamani and Tsiotras's (2001) study on Greek companies concluded that the development and certification of a quality assurance system according to one of the ISO 9000 standards could offer a good first step towards TQM; (2) Sun and Cheng's (2002) study on Norwegian companies concluded that the proper combination of ISO 9000 and TQM would produce more benefits for both SMEs and large firms; (3) Costa and Lorente's (2004) study in Spain concluded that the soft variables of TQM are responsible for the improvement in results derived from TQM implementation; (4) Bikshapathi's (2011) study of SMEs in India concluded that there is a strong relation between ISO certification and TQM implementation and that there is a better result when TQM is implemented in ISO certified companies; and (5) Rohaizan and Tan's (2011) study in Malaysia concluded that *process management*, *customer focus*, and *leadership* are the first three significant factors contributing towards TQM. For the construction industry, Mahmood *et al.* (2006: 2) suggested that internationalization has motivated construction firms in most countries to be actively engaged in trying to achieve internationally accepted quality levels based on two major framework of TQM: the ISO 9000 and quality award criteria. Noting that there are differences in the degree of adoption of TQM among different countries, Mahmood *et al*. (2006: 2) supported that TQM has reached an integrated set of commonly accepted practices as a result of these two frameworks.

TQM and the role of National Quality Award (NQA)

Heras *et al*.'s (2011) study in Europe found that organizations' motivations to implement the ISO 9001 standard were diverse in nature (internal and external), while their motivations for TQM's implementation through the European Foundation for Quality Management (EFQM) seemed to be generally internal. However, an attempt at a direct adaptation of TQM without due considerations for the underlying cultural differences of the people within an organization would not augur well. Jäger (1996) studied TQM motivation in Austria through the National Quality Award (NQA), Ngowi's (2000) study in Botswana concluded that the receptivity of TQM is also influenced by the national culture, Noronha's (2003) study for China, Hong Kong and Taiwan concluded that a culture-specific TQM is created when TQM is implemented in a cross-cultural context, Babatunde and Low (2008) proposed a cross-cultural quality implementation model for Chinese construction firms in Nigeria, and Nitin *et al.* (2011) identified several TQM innovations, categorized them broadly into *award-based frameworks* and *researcher-based frameworks* and opined that the future would see more of NQAs through improved knowledge of TQM based on the two frameworks.

NQA as a possible boost for TQM implementation in Nigeria

Nosakhare (2000: 8) found that while many top executives of organizations in Nigeria were aware of TQM, the level of actual implementation was very low, which is unsurprising considering the dire state of ISO 9000 standards in Nigeria during the time (refer to Figure 1). Adeoti (2011: 20) emphasized that with the political will available, commitments would follow and drive TQM. Akeusola and Ofulue (2011: 15) also concluded that Nigeria could promote the quality of its academic programs by embracing quality in a more holistic manner. Thus, it can be argued that TQM campaign have gained more relevance in Nigeria. Alonso-Almeida's (2011) study subscribed that NQAs are a good way for introducing and developing TQM and found that the NQAs in Egypt, Kenya, Mauritania and South Africa are the four currently available in Africa. The study also found that while the NQAs in these African countries were adapted from the more renowned MBNQA and EFQM, differences exist due to the cultural differences. Little wonder that, save for Mauritania, South Africa, Egypt and Kenya recorded ISO 9001: 2000/2008 certificates higher than Nigeria as at end 2008 at 3,792, 1,944, and 257 respectively, compared to Nigeria's 163 (ISO, 2009a: 17). Similarly, NQA could serve as a boost for ISO 9000 and TQM implementation in Nigeria.

RECOMMENDATIONS FOR NIGERIA

Short-, medium- and long-term plans for ISO 9000 and TQM implementation

Having reviewed the literatures, this study recommends to SON to roll out short-, medium- and long-term plans on the implementation of ISO 9000 standards for Construction and Construction-Related (CCR) firms. Recommended *short-term plans* include: (1) pilot schemes of NQAs to already ISO 9000 registered firms that have further excelled in quality initiatives, (2) incentivized ISO 9000 training (workshops, case studies and interactive sessions) for aspiring CCR firms, and (3) a top-management led written proposal from the aspiring CCR firms on their commitments to continuous improvement. Recommended *medium-term plans* include: (1) infusing into the regular audit an examination of quality initiatives beyond mere compliance to nurture TQM and assess for the NQA, (2) non-complying firms to be allowed re-examinations based on top-management led written proposal for improvements, failure of which demerit points can be assigned, (3) clients in Nigeria should embrace QM by insisting on valid NIS ISO 9000 certification for vendors, after all, the earlier example in India have proven that SMEs can successfully adopt ISO 9000, and (4) the NIS ISO 9000 requirement is to form a part of the critical criteria, failure of which non-complying firms are not to be advanced to the next stage in the evaluation for the award of a contract. Recommended *long-term plans* through: (1) continued award of the NQA to emphasize to CCR firms that competitive edge not only hinge on certification, but rather on self-motivated continuous improvement, (2) it is believed that once ISO 9000 standards become well established, TQM would be desirable targets in Nigeria, a brand-conscious nation (Nzonwanne, 2011: 4), and (3) continued influx of foreign players from countries where TQM has already been embraced would continue to drive TQM in Nigeria.

Concerted efforts to improve quality

It would be foolhardy to think corruption is inconsequential in the quality initiatives for the construction industry. As flagged by Goetsch and Davis (2012), once confidence is lost in the ISO 9000 certification, it would vaporize. Thus, this study recommends to the Nigerian government to: (1) establish a transparent coordinating body, which has also been identified as a problem for the construction industry, (2) the coordinating body is to be supported by regulating bodies for consultants (among others, Nigerian Institute of Architects, NIA; Nigerian Institute of Builders, NIOB; Nigerian Society of Engineers, NSE; Nigerian Institute of Quantity Surveyors, NIQS), contractors/sub-contractors (Federation of Construction Industry, FOCI) as well as manufacturers and suppliers, (3) the coordinating body can work together with the SON to ascertain firms' prior registrations with respective regulating bodies and also co-assess in the award of the NQA, (4) the different regulating bodies to empower credible and competent personnel at all levels to discharge assigned responsibilities in the nation's quality drives.

Efforts by the Bureau of Public Procurement (www.bpp.gov.ng/) in Nigeria to create a national database for the registration, categorization and classification of Contractors, Consultants and Service Providers are commendable, and, perhaps, could be extended to also serving the role of the central coordinating body recommended in this study. This present study opines that the *antiquated and bureaucratic system*, *undue subordination of the marginalized personnel*, and *self-devised survival instincts of the majority of the personnel* aggravate into a state of greed on which corruption festers; and that by addressing these trio, corruption can be nipped at the bud. Still, internationalization presupposes the coming together of players with differing perceptions of corrupt practices. Ernst & Young's (2012) study suggested a rising trend of corruption in international businesses and, in consequence, recommended conducting more frequent and more robust anti-bribery/anti-corruption risk assessments. This study also advances to SON to constantly review SONCAP and MANCAP to clamp down on the connivance of unscrupulous personnel and in the spirit of continuous improvement on which TQM is premised.

Central to the fore going recommendations would be increased challenges for the project managers (PMs) in Nigeria. Generally, PMs' responsibilities for ensuring quality seem elusive and often another source of perceived professional negligence and liability. This could be appreciated by contrasting quality as defined earlier in this study with Leong's (1991: 246) accountability submission that failure to meet a client's overall needs is often the result of failure of the management task. Still, Leong (2001: 260) decimated that with the very unique nature and operating contexts of the profession, the liability could in the extreme case be closely equated with damage represented by the total failure of a project as opposed to losses specifically arising from individual project events. Chib and Harris (2012: 177) also subscribed that frequent adaptations and adjustments away from the pre-defined course of action could become problematic for PMs who are restricted within the bounds of a project's logical framework. Nevertheless, given the concept of TQM, this study recommends to the PMs in Nigeria to, within reasonable practicability, face the challenges on the overall quality of services with aplomb. With the profession's increasing awareness, its accountability would soon be better defined as exemplified by initiatives of more culturally sensitive project

management guides in Nigeria (Onalaja, 2012) and the new ISO 21500 (Guidance on Project Management) (ISO 2012c) to improve project management worldwide.

Furthermore, the recommendations are presented in the proposed model of ISO 9000 to TQM for the Nigerian construction practitioners as presented in Figure 2. SON's first Nigeria Quality Summit held in December 2012 with experts' contributions from Sweden, Malaysia, South Korea, South Africa and Kenya (Anyamele, 2012) also suggests that efforts are underway for a quality revolution in Nigeria. The Nigerian construction industry can also emulate the roles of coordinating bodies in countries such as Australia (Australian Procurement and Construction Council, 1997), Singapore (Construction 21 Steering Committee, 1999) and Hong Kong (Construction Industry Review Committee, 2001). These three countries have been inspired by Sir John Egan's seminal report on the UK construction industry (Egan, 1998) to evolve suitable strategies towards the development of a more competitive and productive construction industry in their respective countries. Similarly, Nigeria can also learn from the other four African countries (Egypt, Kenya, Mauritania and South Africa) that have evolved their own NQAs (see Alonso-Almeida, 2011).

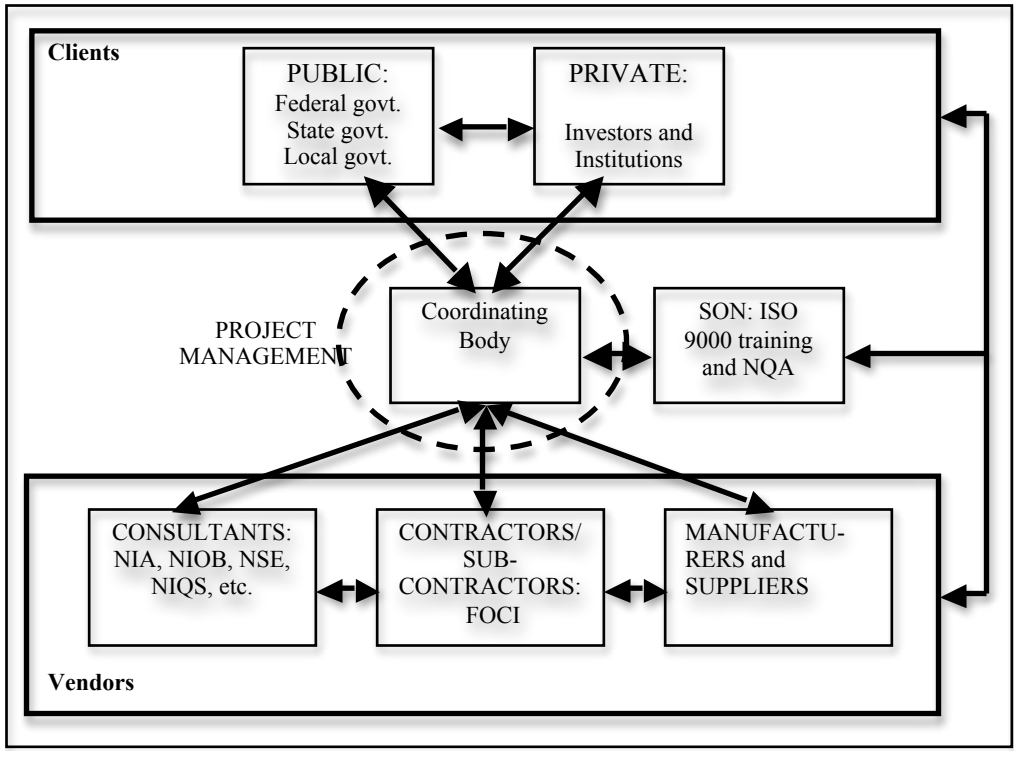

Figure 2: Proposed model for ISO 9000 transition into TQM in the Nigerian construction industry.

CONCLUSION

Reference to the aim and objectives, this study has found that ISO 9000 standards, albeit being the more common QMS in Nigeria, have yet to be fully embraced. Nigeria considerably lags behind the other two large economies in Africa in the adoption of ISO 9000 standards. Reasons can be attributable to the myths disguised as challenges and distorted understanding of the ISO 9000 standards, which this study has addressed by investigating the key tenets of quality and national quality imperatives. The considerably low adoption of ISO 9000 standard has borne on the knowledge and adoption of TQM and created a wide gap. Nevertheless, this study has found ISO 9000 to be a critical first step towards TQM and recommended short-, medium- and long-term plans to nurture towards ISO 9000 and TQM implementation as well as propose a model bearing on concerted efforts by construction practitioners to raise quality standards as presented in Figure 2.

This study's limitations have been restricted to ISO 9000 QMS certification in Nigeria. Similarly, other management systems geared toward continuous improvement exist beside TQM (e.g. Lean system and Six Sigma) and adaptable from the ISO 9000 QMS. Nevertheless, this study assumed that ISO 9000 QMS and TQM would augur well in Nigeria as against other systems, which have remained alien to the majority of Nigerian construction practitioners. A future study can investigate the fore goings. Granted that ISO 9001 certification (or other forms) would confer a form of credibility in an organization's QMS, however, it begs the question as to whether an organization that has diligently practiced good QMS albeit been unregistered could advance straight to implement TQM or must TQM be, necessarily, premised on a prior QMS certification? Or are there other ways that the majority of the uncertified firms have been delivering quality? A future study can also investigate this for Nigeria.

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HAZARDS RELATED TO PETROL FUEL STATIONS DURING OPERATION AND MAINTENANCE

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Abstract
Petrol Fuel Station (PFS) is a kind of facility within urban and rural environment that stores and sell flammable/hazardous material. At PFS availability of flammable and hazardous materials and operational activities poses significant risk to the human life, company assets, and environment. A minor negligence can cause any catastrophic event that may leads to loss of human life, degradation of company reputation and harmful impacts on environment. Attention to handle these hazardous activities varies from operation to operation and companies to companies, it also depends upon safety culture of an organization. The hazards related to PFS also found different in different period of a year. Limited literature was found pertaining to hazards related to operation and maintenance of PFS. A study conducted and one year data collected from PFS located in different areas of Pakistan. During one year duration 1203 non-compliances were recorded. These non-compliances were categorized into 8 main elements and termed as Hazard Contributing Factors (HCFs). The classification of non-compliances based upon HCFs was carried out on seasonal basis. The paper will highlight the variation of HCFs in different seasons of the year. The result of study helps Health Safety and Environment (HSE) professionals to highlight non-compliances in different seasons of the year and take remedial and preventive actions to make PFS safer.

Keywords: *Fuel, Operation and Maintenance, Seasonal Classification, Hazards Contributing Factors*

INTRODUCTION

Petrol Fuel Station (PFS) are of significant importance in urban as well as in rural areas. They store and sell flammable and volatile material. The most common material that sells from these PFS is petrol, diesel, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG) and kerosene oil. Petrol, diesel and kerosene oil is the main source of fuel used for vehicles. Petrol is a mixture of lighter liquid hydrocarbons. Diesel is composed of higher petroleum fraction that has longer chains, therefore, it has a higher density. Availability of PFS in urban and rural areas creates harmful effects on human health, atmosphere, water andsoil(Fogg, Meays *et al*. 1998; Happel, Beckenbach *et al*. 1998). In a recent study conducted by (Sapari, Idris *et al*. 2011) , it was proposed that many urban rivers, lakes and ponds were rendered unfit for use as drinking water sources due to pollution from PFSs. During study period one year data was collected and 1203 non-compliances were recorded. The non-compliances were recorded 24 hours a day and 30 days a month. It was recorded that non-compliances were occurred either due to unsafe acts by the workers or either due to unsafe working conditions (Shariff and Norazahar 2012).

LITERATURE REVIEW

There are various hazards associated to the PFS. These hazards cause harmful effects on people, company assets and environments. PFS are equally important for urban and rural areas as these are the only source of fuel supply to the vehicles. The PFS business requires a large amount of vehicular movements. Normally the fuel supply from fuel depots to the PFS by Tank/Lorries (T/Ls). The public arrival and departure to the PFS is also another form of hazard to the PFS. As there is a probability that vehicles that are coming to take fuel may contain flammable materials that can extinguish within the PFS premises. Therefore the hazards associated to PFS can be divided into two main categorize. i.e. onsite hazards and offsite hazards. The study conducted by (Yimrungruang, Cheevaporn et al. 2008) investigated that at gas service stations workers exposed to high level of Volatile Organic Carbons (VOCs). It was also reported that transport generates VOCs due to evaporation and refuelling of motor vehicles is also a major source of VOC in environment (Majumdar, Dutta et al. 2008).

Various hazards associated with petrol fuel stations were reported in studies; such as fires and explosions due to open flames reported by(Hassanain and Al-Mudhei 2006; Ahmed, Kutty et al. 2011; Ahmed, Kutty et al. 2012), static electricity by (Nabours 2004), air pollution induced by aromatic organic compound concentrations by (Lin, Chiang et al. 2005), and the traffic jams due to vehicle queues to access the petrol filling station (Ismail 2009). It was found that these HCFs were not independent with each other, they have a strong correlation.

HAZARDS RELATED TO PFSs DURING OPERATION AND MAINTENANCE STAGE

Hazards posed by activities are different from one operating sector to another. The hazards that can pose a significant risk to the construction industry are not the same as for the petroleum industry. The non-compliances recorded during operation and maintenance of PFS produce variety of hazards that may cause fatalities, accidents, incidents and near miss cases. Therefore, to prevent unwanted scenarios, each sector's hazards require a different strategy. A PFS is a unique facility that contains stores and sells a flammable and hazardous material within close vicinity in rural and urban areas. Hazards related to PFS operations can be mainly divided into two categories, i.e., onsite hazards and off site hazards. Fire hazards, static electricity, and air pollution evoked by aromatic organic compounds are major causes of accident/incident occurrences at fuel stations. There are other potential hazards in fuel station operations which makes them unsafe. Activities such as carelessness, maintenance, housekeeping, slips, trips and falls, transportation hazard, major and minor injuries, robberies and snakebites have a potential to create unsafe conditions. The level of risk of these hazards varies from PFS to PFS as it depends upon HCFs. PFSs are exposed to on-site hazards as well as off-site hazards. On-site hazards were belong to inside facility PFS hazards that may cause due to inside facility components such as malfunctioning of dispenser units and fuel pumps, underground storage tanks leakages, electrical sparks, fuel spillages, CNG gas leakages, cylinder burst accidents, electrostatic discharges and etc. While off-site hazards were related to those caused that may arised due to external factors. It mainly contributed by people who visit PFS to take fuel. As variety of vehicles arrived at PFS to take fuel.A Figure 1 shows a commonly observed off –site hazard exposed by the PFSs.

Figure 1. A truck arrived at PFS contains numbers of gas cylinders.
It can be a potential source of ignition and cause of high scale fire event.

The non-compliances recorded during the data collection phase indicated that safety conditions atPFS'swerenotappropriate.Atotalnumberof1203 non-compliances were recorded duringaoneyeardatacollectionperiod.Thesenon-compliances were groupedundereightclassificationsandtermedasHazard Contributing Factors(HCFs). It was recorded that these HCFs caused fatalities, accidents, incidents and near miss cases. They also have harmful impacts on humans, environments and company assets. With availability of adequate layers of protection the risk for occurrences of these hazards can be minimized. The HCFs recorded during the operation and maintenance of PFSs was as follows:

- Housekeeping (HK)
- Transportation Hazard (TH)
- Slips, trips and falls (STF)
- Carelessness (C)
- Fire Risk (FR)
- Electrical Faults (EF)
- Miscellaneous Cases (MC)
- Medical Treatment Cases (MTC)

SEASONAL DISTRIBUTION OF NON-COMPLIANCES BASED UPON THE HCFS

The seasonal classification of HCFs introduced with reference to this study found very successful to analyze the data. A study conducted by (Hawkins and Fuller 1999) to measure lost time injuries among professional and youth players on seasonal basis. The data for the study was collected over the period 1994 and 1997. The injury frequency in youth players found to increase in second half of the season and it decreased for professional players. The seasonal distribution of data is normally used for large epidemiological studies. The variation in numbers of workers at construction site was studies by (Adihartanto and Hadikusumo, 2007). In his study work he identified seasonal variation of workers as the potential cause for occurrences of non-compliances. Natural events such as hurricane and high wind during operation and maintenance of PFS were found one significant parameter. It also includes the fogs, mists and dusty environment that especially very important during fuel transportation operation. This aspect is mainly important for T/Ls. The significance of seasonal variations in climatically conditions was studied by (Ozumba, 2001) and notice able fluctuations were reported.

A strong relation among the HCFs with reference to seasons was observed during the study period. The study area contained four seasons: cold, hot, warm and monsoon seasons. The collected data was categorized according to the four seasons. The seasons were named as S1, S2, S3 and S4. Table 1 shows the basis for the seasonal distribution of non-compliances.

Table 1. Bases for Seasonal Distribution of Non-Compliances

Cold Season (S1)	Hot Season (S2)	Warm Season (S3)	Monsoon Season (S4)
Mid November to Mid April	Mid April to June	Mid September to Mid November	July to Mid September

HOUSEKEEPING (HK)

A good housekeeping (HK) practice is an important step to maintain safe and healthy work environment at PFS. Due to bad HK practices, a scrap material was found unattended outside the scrap yard; moreover, an un-orderly pile of scrap material was placed in an open area adjacent at depot. The blowing of heavy winds is found to be quite common and a dominant hazardous factor for PFS's that are located in open areas. Cases have been reported in which due to high wind pressure, trees have fallen on the ground and created hindrances in movement of vehicles and have blocked the passage. It was also noticed that due to heavy winds blowing, the trees swing and touches the high voltage electricity cables. It may cause disastrous circumstances due to the generation of electromagnetic waves. Moreover, it was found that earthing cables were randomly placed on the ground. Emergency exits in offices and store areas were found to be blocked with unnecessary materials. Unsatisfactory water drainage systems were also observed at the PFS.

Fire hazards exist where housekeeping is poor. Fires could be caused by oil-soaked rags and clothing, piles of paper and other packaging materials being allowed to accumulate and being ignited by spontaneous combustion.

TRANSPORTATION HAZARD (TH)

TH can be classified into two main categories, i.e., on-site and off-site hazards. On-site TH consists of hazards that were associated with the movement of T/Ls, other company vehicles and private/public modes of transportation within the PFS facility. While the off-site TH is comprised of hazards related to the mode of transportation outside the PFS facility. On-site hazards that were recorded involved T/Ls include collision with dispenser units, private vehicles, filling gantries, piping systems and with other T/Ls during the PFS operation. Off-site hazards that involved T/Ls were mostly collision with private vehicles. Off-site hazards include many factors such as a driver's perception, condition of T/Ls, road configuration and conditions, traffic congestion on road and the transportation route. Another important feature of fuel transportation via tankers possess higher VOCs loss into the atmosphere (Crawley and Ashton 2002; Majumdar, Dutta *et al*. 2008). Pedestrian injury pattern in Ghana was studied in a study (Damsere-Derry, Ebel *et al*. 2010) the causes of occurrences of pedestrian fatalities were reported being hit by heavy vehicles, speeding, and roadside activities. The study also illustrated that by reducing vehicles speeds in settlements, providing medians on road, installing street lighting in settlement and minimizing roadside activities are helpful to reduce pedestrian fatalities.

The safety record in developing and developed countries has considerable variations. More than 85% fatalities and 90% of disability-adjusted life years lost from traffic accidents occur in developing countries (Mock, Gloyd *et al*. 2003; Olesen and Leonardi 2003; Damsere-Derry, Afukaar *et al*. 2008). Table 2 shows the safety statistical records in different countries (Takala 1999).

Table 2. Work related Fatality cases record in few countries

Regions	Economically active population	Fatal accidents reported to the ILO (2003)	Best estimate: Fatal accidents 2003	Accidents causing at least 4 days' absence Average 2003	Work-related diseases	Work-related mortality	Deaths caused by dangerous substances
EME	427681309	11210	15159	14252505	269989	285148	90400
FSE	193354716	2111	14519	13650601	170166	184685	56976
CHN	740792400	180	97542	91706292	334138	431680	111879
IND	473300000	179	46928	44120055	355863	402791	119153
OAI	457166678	1247	80567	75746706	269541	350107	90250
SSA	273414298	15	57771	54314626	364554	422322	122062
LAC	222632385	2196	31165	29300625	107180	138345	35887
MEC	128010251	929	14296	13441062	73687	87984	24673
Total	2916352037	18067	357948	336532471	1945115	2303063	651279
EU-27	205431242	4422	7460	7013545	159485	166945	73989

Legend: world bank regions
EME=established market economies
FSE=Former socialist economies in Europe
SSA = Sub-Saharan Africa
LAC = Latin America and the Caribbean
MEC = Middle Eastern Crescent
IND = India
CHN = China
OAI = Other Asia and Islands

During this study period, many accidents were reported during fuel transportation. In one accident, two T/Ls during overtaking on highways rolled over along the road. Both T/Ls drivers died on the spot, fuel spilled on the ground and the T/Ls were ruined completely. Figure 2 shows the T/Ls conditions at the scene.

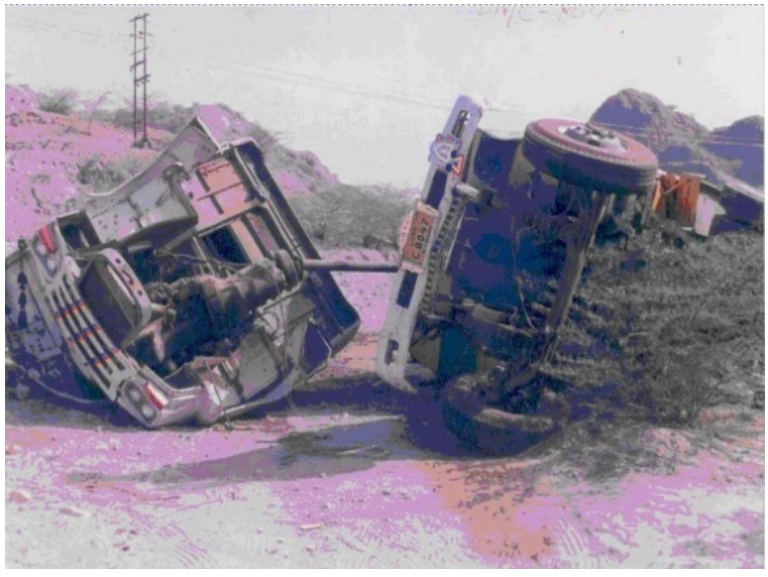

Figure 2. During overtaking on highways T/Ls rolled down from road. Drivers died on scene

Marketing and media plays an important role in petrol fuel retail outlet businesses. Accident occurrences pose a significant impact to a company's reputation and causes business losses. The safety of personnel, customers and the public must be achieved during operation and maintenance at petrol fuel outlets as a first priority (Kikukawa, Mitsuhashi et al. 2009). According to the Federation of Malaysian Manufacturers (FMM) loss prevention fundamentals "loss control may contribute more to profit than an organization's best". It is required for the salesman of a business to sell an additional $1,667,000 in products to pay the costs of $50,000 in annual losses from injury, illness, damage or theft, assuming an average profit on sales of 3% (Federation of Malaysian Manufacturers 2009). Table 3 shows the number of dollars in sales required to pay for different amounts of costs for accident losses, i.e., if an organization's profit margin is 5%, it would have to make sales of $500, 000 to pay for $25, 000 worth of losses. With a 1% margin, $10, 000, 000 of sales would be necessary to pay for $100, 000 of the costs involved with accidents.

Table 3. Sales profits vs. incident costs.Federation of Malaysian Manufacturers (FMM), Loss Prevention Fundamentals

IN TIMES OF KEEN COMPETITION AND LOW PROFIT MARGINS, LOSS CONTROL MAY CONTRIBUTE MORE TO PROFIT THAN AN ORGANIZATION'S BEST SALESMAN					
The amount of sales required to pay for losses will vary with the profit margin.					
YEARLY INCIDENT COSTS	PROFIT MARGIN				
	1%	2%	3%	4%	5%
1,000	100, 000	50, 000	33, 000	25, 000	20, 000
5,000	500, 000	250, 000	167, 000	125, 000	100, 000
10,000	1, 000, 000	500, 000	333, 000	250, 000	200, 000
25, 000	2,500, 000	1,250, 000	833, 000	625, 000	500, 000
50, 000	5,000, 000	2,500, 000	1,667, 000	1,250, 000	1, 000, 000
100, 000	15, 000, 000	5, 000, 000	3,333, 000	2,500, 000	2, 000, 000
150, 000	15, 000, 000	7,500, 000	5, 000, 000	3,750, 000	3, 000, 000
200, 000	20, 000, 000	10, 000, 000	6,666, 000	5, 000, 000	4, 000, 000

Transportation accidents involving releases of liquefied petroleum gases and other petroleum products cause substantial damage to the population, environment and properties adjacent to an accident scene (Van Aerde, and Stewart et al. 1988).

It was mentioned in (Caltex 2003) that motor vehicle and tanker truck accidents were recorded to be the largest proportion in workplace injuries. In the year 2003, there were 64 motor vehicle accidents and 34 tanker truck accidents, including one contractor fatality reported. In the year 2002, there were 54 motor vehicle and 48 tanker truck accidents reported. A graphical representation of motor vehicle and tanker truck accidents is illustrated in Figure 3 below.

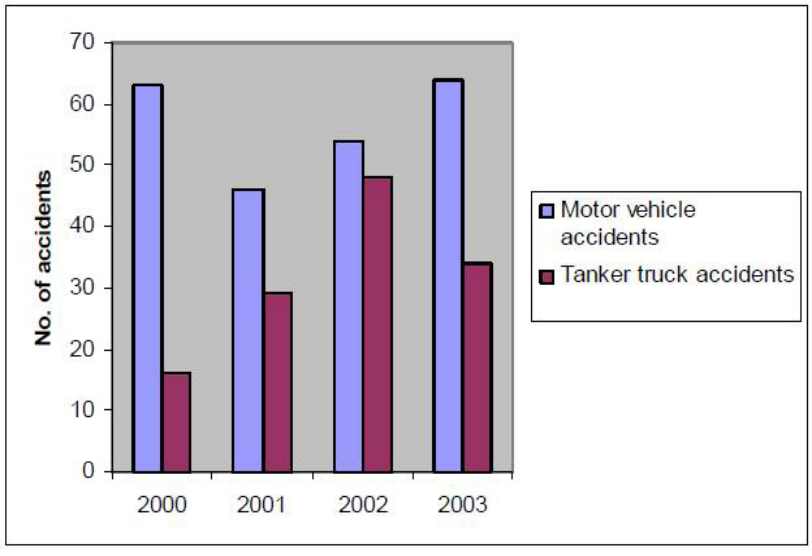

Figure 3. Motor vehicle and tanker truck accidents during the year 2002 & 2003

According to (Leamon and Patrice 1995), 15 percent of all accidental deaths (≈12,000/ year);this is the second leading cause behind motor vehicles.

SLIPS, TRIPS AND FALLS (STF)

Slips, trips and falls were recorded as major causes of medical treatment cases and lost time injury cases. Due to STFs, injuries were reported on the legs, arms and heads of the workers. Carelessness was identified as the root cause in most of the cases. It was also reported that tools falling down during working at heights caused injuries to the workers and pedestrians passing nearby. Falls of workers during cleaning from heights resulted in higher severity of injuries than during other kinds of work. Since PFS's are consideredto be small facilities, less consideration was observed during working at heights. Wooden ladders were found to be in a dangerous state, using the equipment in this condition could result in a serious injury. The overall condition of ladders was to be found not satisfactory. Slippery conditions in the working area at filling gantries were due to minor leakages of oil. It significantly contributed to the cause of STF cases. Workers' casesof slipping were reported while climbing up to the T/Ls after filling operations; major and minor injuries on legs and arms were reported. Major and minor injuries were also reported by the workers due to falls from the roof. A STF cases were reported due the workers' carelessness and faults in the design. Figure 4 shows the gap in the design. It indicates that there is a permanent gap in the design and is a repeated cause of occurrences of STFs. According to (Leamon and Patrice 1995), STFs make up the majority of general industry accidents; over 17% of all disabling work injuries are the results of STF cases.

Figure 4. Diesel dozing pipe.Cause of trip hazard. Permanent design fault and cause of repeatedly occurrences of trip cases.

CARELESSNESS (C)

Contractors and clients have activities that can create major and minor injuries during operations. The number of minor incidents reported in (PSO 2007) were 130 excluding the incidents by contractors. The major cause identified was carelessness. Occurrences of these accidents and incidents show that there was less impact from the available theories proposed by various researchers and working groups to reduce occurrences of cases related to carelessness. With an appropriate approach and scrutinizing of the main causes of occurrences; accidents and incidents cases can be improved significantly. With the application of a behaviour based safety approach and identification of at risky behaviours, safety conditions can be improved. Carelessness happens because of taking the lazy way out. The supervisor or safety inspector cannot eliminate the chances of carelessness from workers but they can remind them and supervise closely the work that they do. Events related to carelessness cases were recorded due to workers;

1. Not following work instructions
2. Not following the set of disciplinary rules and regulations
3. Not using safe working methods
4. Not paying attention to the job they are carrying out or to the operating equipment
5. Using personnel protective equipment improperly
6. Not possessing the aptitude for the complete scope of the work layout plan
7. Possessing insufficient skills required for the work they are performing
8. Not possessing knowledge of the limits and strength of the material being used
9. Not using tools and equipment properly
10. Eye's not being on the task at hand
11. Not possessing a good safety attitude

Carelessness was found to be one of the main elements contributing to hazards during the operation and maintenance of PFSs. Various cases were observed related to carelessness at PFS's. Such as unsatisfactory use of Personnel Protective Equipment (PPEs), improper use of tools and equipment (conditions of tools recorded as deteriorated), inadequate use of signage and instructions, missing signage at desirable locations, use of cell phone in tank zone, not using seat belts while driving, emergency number plates with outdated contact numbers, insufficient medical supplies in first-aid box, sudden application of brakes on T/Ls and other vehicles. Due to carelessness on the part of the driver, T/Ls have collided with other allied facilities at PFS's such as fire water monitors, dispenser units, islands and boundary walls.

FIRE RISKS (FR)

Three main elements are needed to produce fire .i.e. fuel, oxygen and ignition source (Furness and Muckett 2007). PFSs are fuel storage places equally available within urban and rural areas. Fuel has the potential to create fires (McCarthy 1998). The fuel hazard fire assessment is an important input for fire management plans.From 1993 to 2004, approximately 243 incidents related to fires breaking out were reported at PFS around the world (Wouters 2006). Static electricity is produced by the build-up of electrons on weak electrical conductors or insulating materials (Hughes, Ferrett *et al*. 2009). It creates explosion

or serious injury to a person. Electrostatic charges were found to be the root cause of fire occurrences at PFS's. Every year in the USA alone, about 150-200 fires occur due to static-electricity-caused ignition of gasoline vapours(Babrauskas 2005). Electrostatic charges have interaction with weather, clothing, and car seat material as well as getting in and out of a car(Babrauskas2003).Mostoftheincidentsoccurunderlow-humidity conditions; consequently, they are more prevalent in cold weather. Vapour concentration of suspended fuel volatiles depends upon the weather conditions but near surface fuels always burn in anany fire scenario even in situations of lower intensity. A disproportionate fraction of these incidents (55% of the incidents where the ignition details are known) have involved an individual who re-enters and re-exits the vehicle during the fuelling operation (Renkes 2004). Static-prone seats in vehicles allow a high charge to be built up on a person moving in or out of the seat (Von Pidoll, Krämer *et al*. 1997). Although only 5–8 kV values are typically generated by an individual during a single action of getting out of a car, the individual sometimes can produce over 15 kV. Other studies have shown that the charging of an individual to around 6 kV can suffice to produce an incentive spark (Chubb 1998). In terms of responsibility of the individual doing the refuelling, the American Petroleum Institute issued a widely-publicized press release on February 3, 2000, "Do not get back into your vehicle during refuelling". The press release also emphasized that if for some reason the persondoeshavetore-enter the vehicle, "Discharge the static electricity built-up when you get out by touching the outside metal portion of your vehicle, away from the filling point, before attempting to remove the nozzle" (Advisory 2000).

Petrol is a major hydrocarbon fuel; it is a mixture consisting mainly of hexane, octane and heptanes which is extremely flammable. It is able to give off vapours at temperatures as low as minus 40^{o}C that when mixed with air, can give rise to fire and explosions (McCoy, Johnston *et al*. 2002). Many fire case accidents were reported in many studies such as (Hassanain and Al-Mudhei 2006; 2008). According to these studies, the sources of fire at PFSs are open flames, electrical operating components and static electricity. The fire'scause severe injuries, loss of life and damage or destruction of the PFSs site as well as major impact on the surrounding infrastructure. These studies also suggested that there is a need to give sufficient distance between PFSs located at residential sites or other sensitive facilities. It is equally important to give distance between the PFS's and high voltage overhead lines as well.

In 2002, there were three fires, each causing damage exceeding $2,000, as compared to only one in 2003 as reported by (Caltex 2003). The number of minor fires reported has increased since 2001. This increase was attributed to a larger number of small fires reported by the marketing business and not increases in the reported fires at the refineries.

During this study period, fire incidents were reported during the operation and maintenance of PFS's is shown in Figure 5 and Figure 6.

Figure 5. T/Ls caught fire on road during transportation of fuel.

Figure 6. T/Ls caught fire at parking yard.

ELECTRICAL FAULT (EF)

Electricity is a source of energy but when it accidently brought into contact with people permits release of energy which may result in serious damage or loss of life. When electricity comes in contact with other components it may produce heat and sparks. The principal hazards associated with electricity are electric shock, electric burns, electrical fires and explosions,arci ng,portableelectricalequipment(Hughes, Ferrett *et al*. 2009).

A PFS is a hazardous facility and needs special care in the design and installation of its electrical systems which must remain safe and secure throughout the life span of the station so as not to cause explosions or other untoward incidents. Electrical equipment was found to be one of the major causes of fires and explosions during the operation and maintenance of PFS. Pictorial representation of some weaknesses in electrical components that leads to recorded electrical faults cases are shown in Figure 7, Figure 8 and Figure 9.

Figure 7. Unsafe electrical connections in power generation room.

Figure 8. Electric cables trench was found uncovered. Irregular cables in trench.

Figure 9. Uncovered electrical cable trench in power generation room.

MISCELLANEOUS CASES (MC)

Miscellaneous cases are comprised of hazard contributing factors falling under the following classifications:

- Oil spillages
- Water leakages
- Snakebite cases
- Minor damages
- Maintenance issues
- Robbery
- Theft
- Natural disasters/wind storms
- Law and order situations

Due to the lack of safety awareness by the staff, many unsafe practices were noted, including the failure to clear oil spillages, unsafe manual handling practices and the storage of fuel samples in unmarked mineral water bottles. This indicated poor supervision and lack of training. A safe and environmentally friendly disposal was required to clean out spillage and leakages. The worker was found to be careless when dealing with these leakages and was unaware of the need to take action when small spillages of lubricating oil, liquid hydrocarbons, liquid chemicals or hazardous toxic chemicals (liquid or solid) occurred. The spillage of waste generated must be disposed of in the correct manner. It is the responsibility of the person/department supervising the operation to categorize the component waste product and organize them to be contained and disposed of in line with the guidelines. Where small spillages occur, the affected area should be cordoned off and an absorbent such as sand should be spread liberally over the spillage. Once all the spillage has been absorbed into the absorbent media, it should be collected in suitable containers, labelled and disposed of in accordance with the laid down guidelines. Before attempting to handle the spillage, the nature of the chemical should be checked and the guidelines set out by the supplier followed.

Protective clothing as directed in the vendor's guidelines must be provided. Once the chemical has been collected and stored as directed, the disposal guidelines should be adhered to. A thorough washing of the area with clean water should be carried out once the clean-up has been completed. The dispersant should be used with discretion for environmental reasons. The use of un-compatible couplings was observed and could be a potential cause of spillages. Drippings of fuel from the dispenser nozzles were found at various facilities. They contaminated the ground and could be the cause of a fire. Figure 10 indicates the dripping of fuel during the facility operation. The snakes were observed closer to PFSs that were located in rural areas. But the very few cases were reported in which snakes availability was reported in urban areas. In urban areas snakes may not come closer to PFS due to population congestion and facility small size. Although those PFS that are located in rural areas the area of PFSs is large and VOCs smell may go farther therefore there may be the source of snakes attraction towards PFS. Figure 11 shows the snake that was observed closer to PFS located in rural area.

Figure 10. Spillage of petrol closer to dispenser unit at PFS.

Figure 11. A snake was observed closer to PFS in rural area.

MEDICAL TREATMENT CASES (MTC)

Medical treatment cases were reported in all seven hazard contributing factors. i.e. HK, TH, C, STF, FR, EF and MC. Severe cases were reported during the transportation of fuel from the distribution centre to the PFSs. The gantry used for filling of the T/Ls was observed to be very narrow and 20% of the MTCs were reported at that particular position. Injuries were reported on the head, arms and legs. First aid treatment to the workers was provided at the retail outlet on an immediate basis while in case of any serious injury, the patient was shifted to the nearby hospital. According to (Leamon and Patrice 1995), STFs were of the most frequent types of reported injuries. MTCs contribute to 25% of insurance claims in each fiscal year.

RESULTS AND DISCUSSION

Primarily, thereare three main stages of work. These are preliminary & design, construction & execution and finally the operation & maintenance stage. The research findings presentedi nthispaperwerediscussedindetailthenon-compliances that were recorded during operation and maintenance stage of PFS. The data collected for one year duration from PFS was consisted of 1203 non-compliances. These recorded non-compliances were categorized based upon seasonal distribution into 8 main factors and these were termed as hazard contributing factors. The seasonal distribution of hazard contributing factors for the 1203 non-compliances is depicted in Table 4.

Table 4. Seasonal distribution of Hazard Contributing Factors during the study period

No	Hazard Contributing Factors	Cold Season (S1) Mid November to Mid April	Hot Season (S2) Mid April to June	Warm Season (S3) Mid September to Mid November	Monsoon Season (S4) July to Mid September
1	Housekeeping (HK)	15	6	15	19
2	Transportation Hazard (TH)	94	37	60	64
3	Slips, trips and falls (STF)	87	29	56	43
4	Carelessness (C)	93	26	55	50
5	Fire Risks (FR)	10	1	2	4
6	Electrical Fault (EF)	28	16	25	28
7	Miscellaneous Cases (MC)	95	36	73	75
8	Medical Treatment Cases (MTC)	26	2	19	14
	Total	**448**	**153**	**305**	**297**

It can be observed from Table 4 that the highest numbers of 448, non-compliances were recorded in the cold season (S1) that starts from mid November to mid April. During that period the significant non-compliances were reported due to occurrences of cases related to MC and TH. Noticeable cases pertaining to C and STF were also recorded during cold season (S1). The second highest numbers of 305 non-compliances were recorded during warm season (S3) that starts from mid September to mid November. In this period too, the occurrences of MC, TH, C and STF contributed considerably. Whereas during the monsoon season (S4), and hot season (S2) the recorded non-compliances were 297 and 153, respectively.A significant fluctuations in the occurrences of cases pertaining to Fire Risk (FR) can be seen from Table 4. It can be observed that during the cold season (S1), 10 major cases related to fire eruption at PFS were recorded. One fire incident case was recorded in the hot season (S2). In the warm season (S3) and monsoon season (S4) the recorded fire cases were, 2 and 1, respectively.

CONCLUSION

Based upon one year study period and recorded 1203 non-compliances during operation and maintenance of PFS it can be concluded that PFS are not safe workplaces. They need true attention and care during their operation as they exposed to on-site existing hazards as well as hazards that can be posed by external factors. Since their availability is essential within urban and rural environment and it can be expected that with continuous growth and development the numbers of PFS would also be increased. Therefore, safe working conditions and safe work environment is highly essential during PFS operation. As PFS stores and sell flammable and hazardous material within urban and rural areas, the minor negligence has the potential to cause catastrophic event. The situation becomes more dangerous if the PFSs located near public places such as schools, shopping centres, residential areas and flats. Close monitoring is needed during the vehicles and underground storage tank filling operation as these two are the most frequent hazardous activities during operation stage at PFSs. During study it was also noticed that safety conditions at PFSs that was located in urban areas was better as compared to those PFSs that was located in rural areas. It was due to close monitoring of PFSs by the operating companies.

RECOMMENDATIONS

In view of the study results it is recommended that further research shall be carried out to enhance the safety measures at PFS. As the importance of existence of PFS within urban and rural areas can not be ignored.

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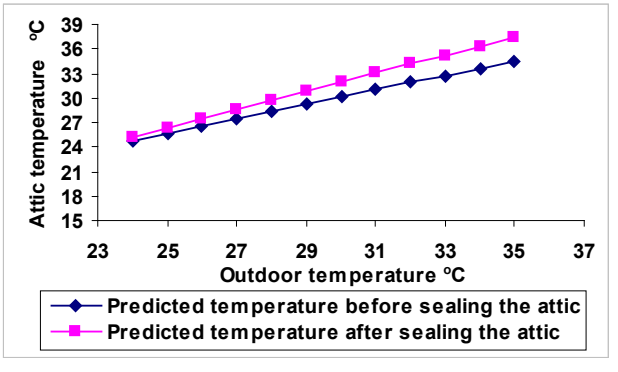

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Figure 8. Computed attic temperature with sealed and ventilated attic

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Table 1. Recommended/Acceptable Physical water quality criteria

Parameter	Raw Water Quality	Drinking Water Quality
Total coliform (MPN/100ml)	500	0
Turbidity (NTU)	1000	5
Color (Hazen)	300	15
pH	5.5-9.0	6.5-9.0

(Source: Twort et al. 1985; MWA,1994)

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