EDITORIAL

Dear brothers and Sisters,

I would like to begin this issue by wishing you a happy new year. We begin 2016 a new, filled with hope that our continued contributions will achieve the society's vision, follow its mission and serve our beloved country in all fields.

We ended 2015 on a high note, with many accomplishments and achievements that speak to the Society's dedication to the industry and the country. Notably, the BIPEX convention and exhibition was held in 2015 after a five-year halt. The main activities of the exhibition are covered in this issue.

2015 also marked a loss for the Society as we mourn a great leader, a pioneer architect and a lover of Baghdad, Dr. Mohammed Saleh Makeeya was a founder of modern Arab architecture. We also lost our dear colleague Engineer Ebrahim Al Majid. May both their souls rest in peace in god's heavens. In this issue we highlight some of their achievements.

Last year commemorated His Royal Majesty King Hamad bin Isa Al Khalifa, the King, may god protect him, awarding first degree competence to nine Bahraini engineers as a part of the National Day celebrations and Coronation day. This is a great honor for all the Bahraini engineers and the Society.

Finally, we look forward to this new year with optimism and hope that it will be a great year and will bring development, growth, and peace.

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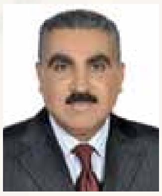

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BAHRAIN SOCIETY OF ENGINEERS
يوم المهندس البحريني

From the Desk of the President

Masoud Ebrahim Al Hermi
President

Dear members,

I am pleased to extend my sincere wishes and greetings to you on the occasion of National Day and the birthday of our Prophet Mohamed, peace and prayer be upon him. I would also like to take this opportunity to convey my very best wishes and sincere thanks to all of you as we wrap up an eventful 2015 and shift our momentum into the next calendar year; praying to the Almighty that this year will be a prosperous and fruitful year, full of achievements for the Kingdom of Bahrain and BSE.

Under the patronage of His Excellency Sheikh Khalid bin Abdulla Al Khalifa, Deputy Prime Minister, BSE organized the "Bahrain International Property Exhibition - BIPEX 2015" during 5th – 7th November, 2015. This surely has been one of BSE's major achievements in 2015. In this issue we shed light on this prominent event that took place after a 5 year interval from its last edition.

BSE derived its inspiration in organizing this prestigious event after a long absence, in view of the Kingdom's pronounced economic improvement ensuing the restoration of confidence and renewed interest in the real estate sector in Bahrain. The governments' expenditure on infrastructure has contributed to the promotion of non-oil sectors being one of the many benefits this reflects. It also facilitated in driving economic growth to an average of up to 4.5% in 2014. The aftermath demonstrated the wise and proactive vision of the Government in the Kingdom of Bahrain, which has maintained the momentum of economic growth by adopting well-balanced financial policies.

According to the survey, conducted by BSE, the exhibition was held in perfect timing and succeeded in shedding light on the latest real estate products in the Kingdom of Bahrain.

BIPEX 2015 proved to be a leading exhibition in the Kingdom of Bahrain, and achieved tremendous benefits for participating organizations, real estate professionals, investors and notably to the public. BSE is looking forward to continue organizing this event in the coming years.

With your support and cooperation, BSE will continue its constructive efforts to leave a clear imprint in the engineering sector and the Bahrain's community in general.

I wish you all a pleasant literary journey through this issue of Al Mohandis Magazine

Masoud Al Hermi
President

Mohammed Al-Khozaae

Civil Engineer to the President of the Capital Municipal Council

Discourse with Mohamed Al-Khozaae, from a mere Civil Engineer to the Chairman of Capital Municipal Council, a passage filled with major achievements

"Greater Muharraq Park" was the first mega project he was involved in

Engineer Mohamed is a self-made man who achieved glory on his own, in spite of his family's lofty status and extensive repute as one of Bahraini's trading families engaged in various commercial fields.

A person who sits and speaks with this engineering personality will feel and cannot miss from the very first instance the extent of mystery and simplicity of the personality. He combines and brings together hobbies and interests that differ from one another. At times he is a drawing and painting enthusiast and at the next moment he will be a kitchen and photography advocate.

He had a passion for painting and theater acting and he hardly knew any difference between architectural engineering and electrical engineering. He had at all times the vision of joining the Faculty of Architecture. However, no sooner he engaged in engineering study than he knew the chasm and rift between what is civilian and what is architectural and consequently he set his mind to join the civil engineering discipline when he felt that it was the branch that met his ambitions, particularly he was a graduate of the industrial track when he was in high school.

This personality is Engineer Mohammed Al- Khozaae, the President of the Capital Municipal Council, who was a witness of his father's passion for volunteering work and which planted in his soul the love and passion for similar endeavors. This he managed to polish and hone during his stints under the umbrella of the Bahrain Society of Engineers.
I had the good luck of meeting this prominent "engineering personality" to shed some light in close proximity and to find out more about it.

Early Childhood and Studies:

Our man was born in the month of October 1959 in a very illustrious family in Bahrain engage in pearling. His grandfather was Shaikh Hajj Abdul Rasool Mohamed had been of the greatest of Bahrain pearl merchants in Bahrain.

Although Al-Khozaae family has been engaged in trading since old times, yet the father of Engineer Mohamed Al-Khozaae was at that time a student of BAPCO school and he worked in the company's garage and workshop, specializing in diesel engines, that was until his brother persuaded him to join the trade business. He migrated from BAPCO and diesel engines to commercial figures and accounts. The family was engaged in general trading and they were famous at that time by the name of Abbas Ahmed and Brothers.

Engineer Mohammed Al-Khozaae is the eldest of his brothers. He studied part of primary school at Sulaymaniah

Elementary school before he moved on in grade 3 and returned to Ras Al-Ruman area where he finished his elementary education. He studied intermediate school at Abubakr Al- Sidique School. He graduated in the year 1976-1977 from high school with auto mechanic specialization. After graduation, Engineer Al- Khozaae joined BAPCO as a trainee. However, he did not stay for long with this mega company so as to study abroad. Mohammed recalls that while working for BAPCO his father was his direct boss, one of the incidents in his career.

"We left for Poona in India as I was looking forward to study engineering. We were informed that foreigners were not allowed to study engineering, but rather they were enrolled only in sciences and literature disciplines". He had no choice other than study sciences and also enrolled in décor engineering. This was in the year 1977. However, his passion to study engineering prompted him to abandon and drop out of Poona University before completing the study of sciences and to proceed to Bangalore City to join Ramaya University, India, where he secured acceptance to study engineering between the years 1980 – 1981. He graduated after studying civil engineering for five years in the year 1986.

Work and achievements:

Engineer Al-Khozaae was not anxious or quick to work in any of the ministries as his desire was to acquire some experience. Consequently, he joint Al-Khozaae Commercial Group and specifically in the contracting field. Because of the slump in this field during that period, he proceeded to work with other contractors from outside the family. One of the first projects he was engaged in was Greater Muharraq Park as a site engineer with a Bahraini contracting company between the years 1986- 1987. He also worked in a gas station project in Isa Town. He also worked with other subcontractors in the Gulf University in addition to the air base in Sukhir area.

Now that he has acquired the prerequisite experience, he was engaged in independent free enterprise by entering in a partnership with a friend of his in the contracting field. They together implemented a number of assorted projects for a period of almost two years.

During the period from 1990 to 2008, he landed an opportunity to join BATELCO as an engineer in the Projects Department. A few years later, he was promoted to the position of Director of Projects and Services, where he supervised all construction projects of the company all over Bahrain. According to him, he worked for BATELCO for close to 18 years after which he secured an opportunity with an investment company in Bahrain during the period 2008 – 2010, a period which witnessed a boom in real estate investments and during which he executed and supervised many of the company's projects at that time.
He continues to clarify "Similarly, the engineers can also derive benefit from attending specialized seminars and training courses, which Al-Khuzaie went to great length to attend. Ever since that time, the Bahrain Society of Engineers is considered the best organization that offers specialized training programs to its own members as well as other outsiders. For this very reason, I have always pride myself for being a member of this illustrious professional society without which I would not have been what I am today".

Mohamed Al- Khozaae's firm belief is that BATELCO is a unique school per se, especially as it is a mega communications building. During his stint with the company, he earned massive benefit from the intensive training courses that BATELCO, as an important economic edifice in the Kingdom of Bahrain, goes to great length in order to develop and qualify its employees. The most important courses that Eng. Mohamed Al-Khozaae engaged in involved courses in management and project management which all had a beneficial and positive impact on him, particularly where the management of his own business was concerned.

During that period he was a member on the Expropriation and Compensation Committee. This is a committee composed of representatives of both the private and public sectors. It is tasked with review of the requests filed by government ministries to expropriate and sequester lands in the public interest. He also presided over the technical committee, an offshoot of the mother committee. This too helped him to acquire experience in valuation of lands and assessment of buildings.

Working in the Expropriation and Compensation Committee also motivated him to move his steps once more toward the private enterprise. He opened in 2010

Al-Khuzaie Office for Real Estate Valuation and Assessment. Al- Khuzaie developed the assessment process using the American system, thereby devising in the year …. a computer- assisted land assessment software. However, because the market, especially the modern programs for valuation market, did not accept such programs and was not encouraging for sustainability, Al-Khuzaie soon abandoned this type of free enterprise and focused on contracting.

Proceeding to Qatar

In the year 2011, Eng. Mohamed Al-Khozaae received an employment offer in the State of Qatar with a major investment company in the position of project manager. He worked in several projects, thereby beefing up his experience in the area of mega projects' design and execution. The most salient of these projects is a five

star hotel project. However, he did not last for long with that company on account of being away from his family, which forced him to give up working for that company so as to be close to his family and continued to resume his business in contracting up to the year 2014.

President of the Capital Municipal Council

In the month of December 2014, to be exact, Eng. Mohamed Al-Khozaae earned the distinct honor of being appointed as the President of the Capital Municipal Council by His Royal Majesty King Hamad bin Isa Al Khalifa, King of Bahrain.

Commenting on this development, Al-Khozaae said "landing this job by the grace of His Majesty is a source of my pride and a real reflection of the keen desire of our leadership to promote and develop the Bahrain community and the youth categories", adding that "this is, indeed, a great opportunity to do my duty to my beloved country".

Family life:

Mohamed Al-Khozaae's first baby was a beautiful girl named "Naba" who has passed away in a car accident tragedy, she was active in social voluntary work and through Diabetes Society in particular .He is now left with two sons, Talal and Hisham, both studying engineering in Germany. Talal is studying building and environment engineering, while Hisham is studying material engineering. His wife is an employee of a local bank and has nothing to do with engineering.

He muses "I never gave my sons any guidelines or intimation to study any engineering discipline. As a matter of fact I did not expect my son Talal to engage in building engineering in particular. I left the door wide open for them. However, Hisham had a passion for chemistry and physics and hence his choice for material engineering.

Joining BSE and Volunteer Endeavor

Engineer Al-Khozaae recalls: "when I was a small boy, I say my father, Ali Al-Khuzaie paying due attention to and care for volunteering work. My father is considered one of the oldest heads of clubs in Bahrain and all this reflected

favorably on my personality. I love to extent assistance to the others and I do love volunteer and so was the case during my college life. Joining the Bahrain Society of Engineers, the Society further boosted and consolidated, thanks to its activities and functions this side of my personality".

His tenure with the Society further progress to function as a director on the board in 1997 where he was engaged in several committees and he headed some other committees. He served as manager of social activities up to the year 1998. Mohammed Al- Khuzaie describes this period as being the most active through the history of the society, organizing activities and functions for the membership and where a spirit of love and camaraderie prevailed among the members.

During his stint in the Society, Al- Khozaae executed several programs and activities which boost and consolidate the standing of the society in the Bahrain community as a professional concern.

In the year 2002, Al- Khozaae served as secretary of the BSE which enabled him to be acquainted more and in stronger sense with the Bahraini engineers and others from the Arab countries through the Arab Engineering Federation.

Al-Khozaae explained that this diversity in the positions he filled in the Bahrain Society of Engineers drew

a vivid picture of the importance of this professional organization for the Bahrain community. He explains that "the engineers under the umbrella of the Society certainly derives tremendous benefit not only from the professional association and from the expertise abound in it but also from the experience available outside it. All this reflects favorably on the development of our work as engineers be it in free enterprise or as part of organizations in both the public and private sectors".

He continues to clarify "Similarly, the engineers can also derive benefit from attending specialized seminars and training courses, which Al-Khuzaie went to great length to attend. Ever since that time, the Bahrain Society of Engineers is considered the best organization that offers specialized training programs to its own members as well as other outsiders. For this very reason, I have always pride myself for being a member of this illustrious professional society without which I would not have been what I am today".

During the period 2002 to 2003, Al-Khozaae filled the post of Vice President of BSE, about which he comments: "it is my own good luck that I associated through the Bahrain Society of Engineers with a number of highly qualified engineers, such as Engineer Dheya Tawfiqi, Engineer Saeed- Alasboul, Engineer Mohammed Khalil, Engineer Abdul Majid Al- Qassab and Engineer Masoud Al- Harmi, the incumbent president of the Bahrain Society of Engineers and many other members with premium extensive experience".

Engineer Al-Khozaae still narrates the tale of how he joined the Society, saying "after the year 2003, I had no choice but to withdraw from the Board of Directors in accordance with the Society's rules and regulations as two cycles have elapsed since I joined the Board of Directors and for this reason I had to exit the Board of Directors. However, I returned to the Board of Directors one more time in the year 2005 as Secretary and Manager of External Relations. He commented that he was very happy with this post in particular, especially has he managed to strengthen his external relationships and rapport with the engineers from all over the Arab world".

Meanwhile, he was also a member on the Strategic Committee of the Arab Engineers Federation. This committee is set up of group of members from the Arab countries. The most prominent lessons he learned is how to devise a strategy for non- profit organizations.

During his engineering career, Engineer Al-Khozaae filled the position of a member of the Permanent Committee of the Arab Engineering Federation, a committee tasked with tracking and following up on the affairs of the Federation, relative to execution of the resolutions and recommendations proposed by the Federation. It also serves as a liaison link between the executive office, the engineering commissions and the Secretary General of the Federation.

Role of BSE and the Engineering Profession

The Society managed to function as a platform for supporting the engineers, both students and functioning engineers in the engineering sector. The outgoing engineering commissions and departments filed certain requests to the official agencies for provision of statistics and figures showing the engineering specialties and the challenges that the official agencies face so that the Bahrain Society of Engineers may extend the necessary and valid support and aid to the engineering students or practicing engineers working in the engineering sector. However, the Society has not received the required data and information, especially from the Central Information Body.

There is also a prevalent persuasion of the importance of convincing the students of the benefit of pursuing certain engineering fields based on the labor market needs. Hence is the role of the Society which involves organization of several related functions the most important of which is “Engineering Career Day”.

Farah Al Halwaji
Chemicial Engineer

The Barriers and CSF for Fruitful Projects

Abstract

History has a very strange way of repeating itself. Organisations continue to repeat the same project management sins time and time again. At times, often too many, it is not the first project team to reach the very same conclusion – the adopted approach is too complex, the key stakeholders are not on the same page… and the list goes on. All of these 'signs' are indicative of an unsuccessful project. How many times have you been in a similar situation? What are the root causes behind these clichés and how can organisations avoid them?

Extensive literature on the 'Lessons Learnt' topic seems to be limited, which leads to the lack of awareness within organisations on its importance. Therefore, the objective of this paper is to explore the key barriers that organisations face in embracing an effective lessons learnt culture and illustrate how they can be avoided. The approach taken to develop this paper is two folds: comparison of available literature to extract insights, and most significantly, validation of these insights with professionals within the Project Management field across diverse industries through interviews.

Organisations say that they have a formal lessons learnt process in place; however the practice is often resisted, and if it is put into practice then it might be superficially implemented. The two main barriers to adopting a lessons learnt culture are: lack of leadership involvement, and inadequate and ineffective lessons learnt management processes within organisations. To overcome these barriers, there are three critical success factors that organisations should consider:

1) Strong leadership commitment,
2) Effective tailored approach to utilising people, processes, and technology, and
3) Published benefits-realisation process

A practice from a Government Administration organisation in the United Arab Emirates (UAE) on the methodology they have taken to adopt a lessons learnt culture will be discussed in this paper. The approach that this Government has taken illustrates how strong leadership and a qualified Project Management Office (PMO) were the backbone to creating a lessons learnt culture in the organisation.

Introduction

Two recognised methods of gathering, analysing and sharing learning's are (Jugdev, K, 2012):

- Project lessons learnt approach (more formal approach), and
- Communities of Practice (CoP) (often a less structured approach).

This paper will focus on the former. The purpose of lessons learnt is to reflect on similar past project experiences by understanding the areas of development (faults) and good practices, and then applying these learnings to the current project. Project management involves a variety of processes and practices, including ways in which project teams learn on and from projects. Often, recognising lessons learnt is as simple as asking "What worked well, what did not work so well, and how did we resolve any issues?" All of these questions will help project managers in future projects.

The Project Management Institute's (PMI) PMBOK® Guide defines lessons learnt as "the learning gained from the process of performing the project. Lessons learnt may be identified at any point. It is also considered a project record; to be included in the lessons learnt knowledge base" (PMI, 2010). This definition explains that experiences and learnings may occur at any point in the project lifecycle and, most importantly, it is necessary to capture them. This process may be defined in two ways:

1) Lessons learnt documents are one set of important outputs delivered at the end of the project – which is more commonly practiced in organisations due to the lack of resources.
2) The process could be defined more broadly as: the process of learning (whether formally or informally), takes place throughout the project's lifecycle and between projects.

Projects are usually complex in nature and involve a wide range of challenges. These challenges may be caused by internal factors such as lack of experienced project managers or subject matter experts, contractual issues, staff turner, or external factors such as aggressive local or foreign competition, alliances, volatile market conditions, unexpected environmental factors, etc. All of these challenges and how organisations tackled these problems need to be documented as they are good references for future projects.

Lessons learnt is a helpful way of transferring useful project knowledge – all that is good, bad and ugly – as it constitutes sharing knowledge about the elements of distinct project phases (whether these phases went according to plan or not), the areas that could be improved on, and how these areas were addressed. This effort should be done before moving on to the next phase of the project or the next project in the pipeline.

A lesson can be simple or complex, and the recording of each differs. An example of a straightforward 'lesson' that may be documented is the operation and maintenance of a certain tool. Intricate lessons, on the other hand, often involve more subtle concepts; and the understanding and application of these lessons require full comprehension of the problem.

If lessons are not documented accurately or they are misunderstood by project teams, their applications may result in disastrous scenarios. In order to fully grasp a complex situation, lessons are best shared through face-to-face dialogue with those members who have firsthand experience and are knowledgeable of the challenges and resolutions.

Nick Milton, a knowledge management expert, nicely explains a broader framework to maximising the value of applying lessons learnt practices at various stages of the project lifecycle (Don Dressler, 2007):

- **Learning before or during the planning phase:** Allowing team members to comprehend and apply lessons learnt from previous projects while planning for new projects. This should provide tremendous returns in improved performance. In reality, the most benefit from lessons occurs when they are proactively applied at this stage (before the project is kicked off).

- **Learning during the execution phase:** Lessons recognised during execution can be reinvested back into the remaining execution phase for immediate improvement. This process is often too many times overlooked due to resource limitations, thus it requires a Project Manager who believes in the time (and hence value) spent on discussing those lessons. Most lessons learnt are actually generated in the execution phase of the project

- **Learning at the close out phase:** Lessons based on observation and practical experience across a long period of time offer the best insights on what has been learned from the beginning of the project till the end, and all the subtle learnings in between. This exercise, when done in a team as it should be, offers great team bonding experience and knowledge sharing within and across project teams..

Problem Statement

It is apparent that we fail to learn from mistakes – whether our own or those of others. The process of capturing lessons learnt is often overlooked because it is a time consuming activity usually done at the end of the project lifecycle. It is seldom given priority as project teams are usually quickly reassigned and 'reserved' to new engagements even before the previous engagement is completed. This paper discusses the barriers and critical success factors to developing an effective lessons learnt culture within organizations.

Approach

The paper exhibits findings of analysis done on existing studies to elicit the most commonly experienced barriers and critical success factors with respect to lessons learnt. The findings were validated with professionals within the Project Management field across diverse industries.

Value of Adopting a Lessons Learnt Culture

Reality is that lessons learnt are often resisted for various reasons and hence done superficially. This leads to valuable knowledge gained from a project not being documented in full for future use. Due to the lack of proper and sufficient documentation considerable rework might be required on projects, which in return produces a domino effect of cost and schedule overruns.

Adopting an organisationally accepted lessons learnt culture is fundamental for three key reasons, as depicted in the below figure.

Figure 1: The Value of Adopting a Lessons Learnt Culture

The following section describes in further detail the three reasons.

1) **Better communication and team work:** Over 80 percent of workplace learning occurs informally and hence adopting the culture will enhance communication and team work between project teams and departments. In addition, transferring knowledge (inclusive of lessons learnt) between team members will ensure business continuity as the knowledge is retained within the organisation and not disappeared when a project manager leaves.

2) **Increased competitive advantage:** Those organisations that are mature in the world of project management create and retain knowledge-based assets, thus increasing their competitive advantage. Mature organisations develop practices from a back log of experiences, thus creating a unique set of processes to follow. These processes become accepted and embedded in the culture over time. The asset database also contributes to reason number three mentioned below (improved bottom line) in that documented past project experiences help achieve economies of learning.

3) **Improved bottom line:** By making use of past project experience, milestones will be met or even delivered earlier than scheduled. This will result in better cost management, which will contribute to achieving the desired net profit. For this to actually happen in practice, it is important to achieve results at the operational level throughout the project lifecycle.

Though the importance of embracing a lessons learnt culture is straight forward and clear, there are several key barriers that hinder organisations from enjoying the value it brings. These barriers are discussed in the following section.

Key Barriers to Adopting Lessons Learnt Culture

Understanding the key barriers facing organisations from adopting the culture is imperative for reduced risk of failure and improved project performance. From interviews with professionals in diverse industries, it is apparent that there are two main barriers.

1) Lack of leadership involvement and commitment

The most critical obstacle to the learning process is the lack of leadership engagement. Without management support, all efforts that are undertaken – however good – will be put on the shelf. This quite often results from two underlying causes. The first occurs when management lacks a clear understanding of the above explained framework of "learn before, during, and after". Leadership may view documenting lessons and their application as a one-time event that occurs only at the end of a phase or project. As efforts in carrying out this task are underestimated, this inevitably results in a disruptive level of leadership engagement throughout the project.

The second problem occurs when leadership fails to admit that, although the project delivered the expected outcomes, some things did go wrong. Leadership often tries to disguise the truth and convince the team into believing that the immediate achievement of bottom lines is the ultimate goal. Management need to have a longer term vision and should welcome these learnings by having an unbiased acknowledgement of the truth that no project has absolutely no lessons to be learnt from. This acknowledgement is the first step in honestly applying and benefiting from captured lessons.

Often too many times we hear the three words of 'I'm too busy' – that is, too busy to document what was learned. Such excuses are the underlying reason of natural resistance in any organisation – more work is almost always faced with struggle at the beginning. Therefore, strong management commitment helps to lessen this struggle; this commitment could be in the form of ensuring that adequate time and resources are allocated to projects.

2) Inadequate and ineffective lessons learnt management process

The second barrier is related to not having proper processes in place that deal with the end-to-end management of lessons learnt. Sometimes these are inadequate and/or ineffective due to several factors:

- **Number of lessons available:** Sometimes too many or too few lessons available for project teams to refer to can be a problem. Unless properly referenced and tagged with key terms, if there are numerous lessons in the repository then this can be confusing to the team, as well as time consuming. On the other hand, if there are too few lessons in the repository, project teams may be hesitant to take the time in writing their lessons as they do not see much value in the existing repository. Also, with too few lessons, the repository might not be able to help all project teams as not all topics are covered.

- **Hard accessibility of lessons:** Lessons that are not stored properly can make their retrieval difficult. For project teams to feel encouraged to use the repository, the organisation needs to make it easy to navigate through the many documents. Tagging each lessons learnt document with key words would make the lives of project team members much easier. Some examples of such key words could relate to the project's sector, the functional experience that was needed to execute the project, the duration / cost of the project, and the Project Manager. As well, the user interface of the application used to capture these lessons should be user friendly. Periodic assessment on the validity of these documented lessons should be done to avoid unwanted traffic in the repository.

- **Poor capture of lessons:** The skill of documenting lessons learnt so that they are usable by other project team members is very important. This skills lies in the ability of the documenter to write clearly and in details all that is related to the lesson. A typical example of a lesson that we see documented is 'ensure that the Project Manager applies a reward system through the project lifecycle.' This insight is important, however it does not give full details on what kind of reward system should be implemented, the guidelines that may be used, etc. The PMO would be the ideal people to train the organisation on how to write effective lessons.

- **Untimely lesson documentation and use:** Historically, the norm was to capture lessons only at the end of the project. This is still very much practiced in organisations due to awareness (or lack thereof) and resource shortcomings. The most evident problem with this approach is that some projects may last for stretched periods and project team members may forget the intricacies of lessons, which results in a poorly written document. Key lessons should be documented throughout the project's lifecycle and, as seen appropriate, published to the rest of the organisation even before the completion of the project. This is because some lessons, especially those associated with technology, may become obsolete after some time.

To overcome the aforementioned barriers, there are three critical success factors that organisations should seriously consider looking into. These factors are described in detail in the following section.

Critical Success Factors in Overcoming Barriers

Similarly to short listing the barriers explained above, the below critical success factors were challenged and validated with Project Management professionals through one-to-one interviews.

1) Strong leadership commitment

The most obvious and important ingredient to any new or immature initiative in organisations is ensuring leadership understand the initiative, obtaining their full support on a continuous basis, and creating an environment where team members are not wary to admit their mistakes. Organisations may have the best processes and procedures in place supported by the best in class technologies; however without management support it is very unlikely that best practices can sustain an effective learning culture that enhances both operational and business performance.

Once management are supportive of creating this knowledge-based culture, they must continuously show commitment by asking about how lessons are being managed in the organisation, by signing off on lessons learnt documents, and by ensuring that the appropriate resources are available to help continuous application of these practices. Such resources may include allowing for the time to develop lessons learnt documents and authorising the budget to implement a user-friendly repository system.

2) Effective tailored approach to utilising people, processes, and technology

A customised combination of these resources: people, processes, and technology are necessary to make capturing and sharing lessons a part of everyone's job:

- **Skilled People:** The right people need to be selected to document these lessons; they will need appropriate training (preferably by the PMO) to become proficient in writing lessons and in using simple tools. With time these individuals will be able to even suggest improvements to the lessons learnt management process in the organisation.

- **Simple and Clear Processes:** Processes that are clear and communicated to the organisation are readily followed, especially those that show value to the organisation. At the beginning of each project, the Project Manager has the responsibility of determining the frequency of project team meetings to discuss any lessons learnt from the project, and include these meetings in the project plan. The Project Manager also has the task of communicating the same to the project team so they can prepare for the meeting. One way to engage team members and have them interested in the process is by Project Managers making this a fun session and treat it as a team building exercise, as opposed to a formal meeting.

- **Suitable Technology:** Technology that is too complex to implement and understand will soon be eradicated. Adopting a lesson learned culture in the organisation is a time consuming process as the value of this process is not one that is seen quickly – organisations require ample time to generate a solid lessons learnt database. As knowledge-management expert Nick Milton explained it, "The management of knowledge, like the management of anything else, needs to be systematic rather than ad hoc, and needs to be tied into the business cycle" (Don Dressler, 2007). Technology (software applications) – friendly user interfaces – helps making the capture of lessons and sharing easier for individuals and teams across the organisation.

3) **Published benefits-realisation system**

Showing the value of lessons learnt and setting a rewards system in the organisation is imperative:

- **Demonstrating value:** The value of documentation and analysis needs to be shared with the organisation through creative methods, such as through Learning Luncheons for the entire organisation, each department, or certain project teams. Involving the individuals who worked on the project in presenting their experience will aid in developing a more welcoming culture to the idea of exposing the good, the bad and the ugly.

- **Rewarding individuals:** At the start of such an initiative, leadership should recognise and reward those who write clear lessons learnt, use them effectively, and share them with others. These rewards need not to be in monetary terms – for many people the fact that the CEO is present and engaged while an individual explains his/her part is enough in terms of job satisfaction.

The long-term sustainability of any learning system heavily depends on having strong leadership, a tailored approach to people, processes and the technology used, as well as a shared benefits-realisation system in place. Without these key success factors, it is almost impossible to build a sustainable lessons learnt management system.

Case Study:

The approach taken at a Government Administration organisation in the United Arab Emirates (UAE) to ensure continuous lessons learnt improvement through committed leadership and a qualified PMO In this Government Administration organisation, the PMO plays a vital role with regards to developing customised lessons learnt initiatives for the organisation.

This practice will be explained via the lenses of the PMO and how they have effectively started to embed the lessons learnt culture in the organisation. The initiative was focused on determining the right processes that should be followed, the templates that could be used as a tool for effectively documenting lessons, and training project teams. All of the areas detailed below were shared with leadership prior to implementation, and hence the PMO were able to gain full support for the roll out of this initiative. These areas are discussed in further detail below:

1) Shared and Communicated Processes:

The PMO established the most important rule, which is that all projects in the organisation need to be formally closed by either using a Closure Document or Lessons Learnt Document or both, depending on the reason for closure. Closure Documents are used when the project is closed prematurely and Lessons Learnt Documents are required for both premature ending of projects and projects that are normally closed. The lessons learnt process described below was developed by the PMO based on good practices and shared with leadership to ensure they are on board. The following highlight the main points in the adopted process:

- As projects in this organisation do not span for more than a year these formal documents are often done at the end of the project, however lessons are captured during the lifecycle of the project so they are not forgotten
- The Project Manager is the individual responsible for filling out the tool but input is sought from team members as well as third parties who worked on the project, if applicable. The Project Manager has the freedom to select the method of validating the documented information with the project teams and partner.
- As this initiative is fairly new in the organisation, a member of the PMO is invited to attend these meetings to ensure that all areas have been thought of and covered
- The authority matrix of approving the document is as follows: sign off of the Project Manager, Department Manager, Vice President of the Group, and the Chief Executive Officer (CEO). This ensures that all levels within the organisation are aware of all reasons that projects might have prematurely closed, any issues to look out for in the future, and any positive lessons to leverage from when engaging in similar projects

2) Customised Templates:

The PMO developed a template to capture important areas that management is interested to gain more insight on and to use as references for future projects.

Some of the areas that are captured in the template include:

- Operational performance measures such as planned vs. actual values for cost, schedule, and scope
- Reason for closure, if it was prematurely closed
- Challenges faced in terms of operational activities, inclusive of the engagement and relationship with partners (pros and cons of dealing with them), and how these issues were addressed and by whom. This is especially helpful when evaluating bidders for potential projects
- Risks that the project encountered
- Areas of strength that can be leveraged in the future
- Identification of key words to tag to the lessons learnt document such the industry/sector and type of project the team was involved in. Examples of these may be: 'government administration' and 'strategy development'; 'utilities' and 'business process re-engineering'. These key terms will be used as identifiers in the lessons learnt database for easy retrieval of documents.
- The Project Manager and team members, along with the rationale of why these individuals were chosen for the project

To further ensure that leadership is committed to the success of this initiative, the above explained process and developed templates were documented in the organisation's Project Manual and signed off by the CEO and the Board of Directors.

3) Development of a Generic Mind Map:

The visualisation of the lessons learnt on a project enables the project team to make clear linkages and reveal 'cause and effect' relationships quickly. One of the tools that the PMO in the Government Administration developed was Mind Maps. A simplified version of the Mind Map that was created is illustrated below. This tool ensures that teams discuss every aspect of the project.

4) Organisational Training:

The PMO is responsible for building awareness in the organisation and hence they have the responsibility of training individual Project Managers and team members on how to effectively use the tool. The first time this was done was in a group setting over lunch, and repeated every six months or as the organisation saw appropriate. As mentioned previously, a member of the PMO is involved in the lessons learnt documentation process after the completion of each project, where this PMO representative helps the Project Manager in facilitating the discussion. Also, one-to-one sessions are also conducted based on the request of the Project Managers.

5) Knowledge Sharing:

A lessons learnt is really not learned if it is not validated and made available to others. Sharing the gained knowledge is done on several levels: making the documents available on the intranet for the entire organisation, issuing lessons learnt reports, and conducting lessons learnt gatherings. Each of these three levels are described further:

- Availability and easy access of these documents: This is important as Project Managers will not spend time looking for these lessons. Making them readily available will increase the chance of them being used.

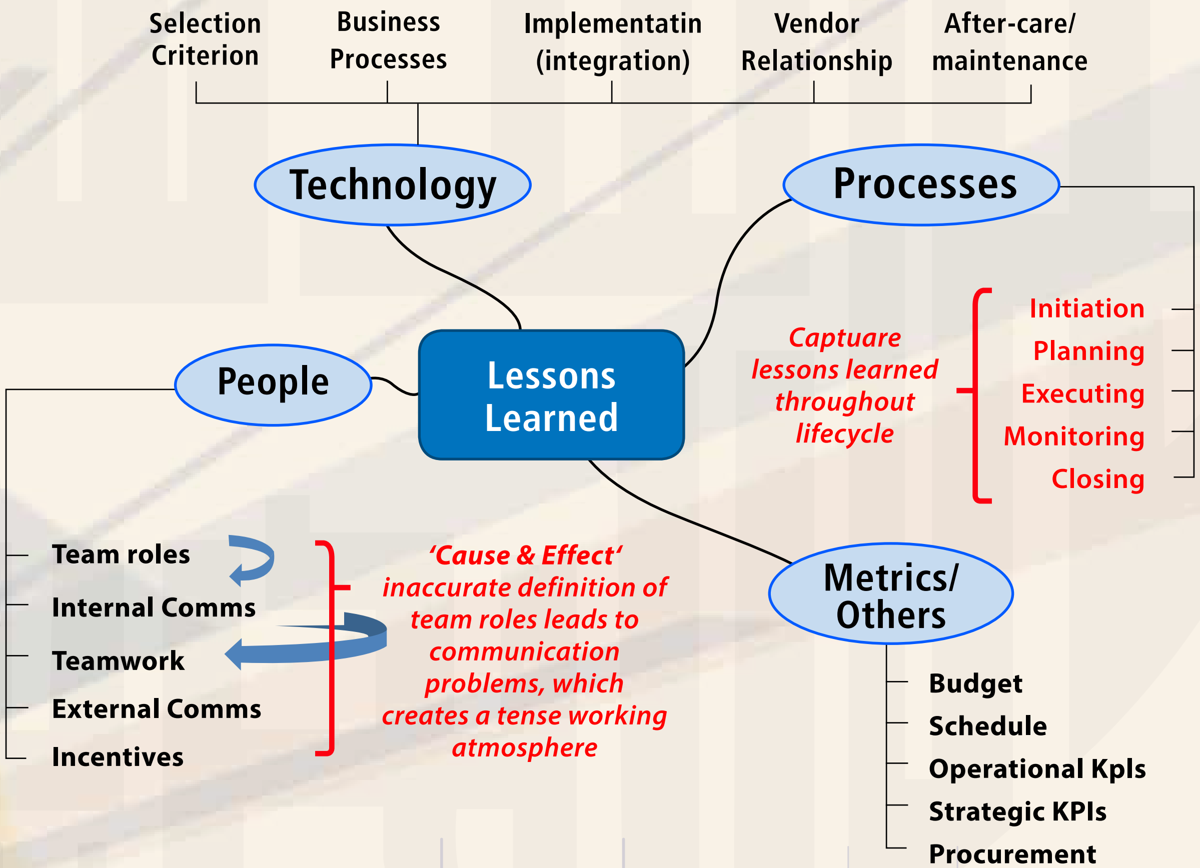

Figure 2: Simplified version of the Mind Map developed by the PMO

- **Lessons Learnt Reports:** The PMO has created an Excel database for all closed projects and this information has been analysed for common themes and trends based on industry and project type. The analysis of this information is presented in reports that are issued to the organisation every six months.

- **Holding organisation-wide lessons learnt sessions:** In addition to issuing reports, the analysis is presented to the organisation in an informal manner during social gatherings. The presentations made on the subject are kept detail requirements in rejecting the proposed material. The silt/clay content greater than 20% and PI>20% are not the sole indication to reject the material. Detail information on clay-sized fraction and mineral tests are further required for this purpose.

short and simple so everyone (hopefully) is kept engaged. Such sessions are aimed to be held annually. The management team, including the Board of Directors, is encouraged to attend these gatherings to show their commitment.

The Government Administration organisation believes that implementing a lessons learnt culture with strong leadership commitment is one of the primary vehicles for continuous improvement and effectively maturing the PMO and ultimately the organisation.

Conclusion

A lessons learnt process allows an organisation to learn from both its slipups and successes. Examining the key barriers to effective applications of lessons learnt is imperative for reduced risk of failure and improved project performance. The main barriers to adopting a lessons learnt culture are: lack of leadership engagement in the process, as well as inadequate and ineffective management of these learned lessons within organisations.

In order to adopt an effective lessons learnt culture, there has to be strong leadership support that encourages and rewards honesty and instills a culture aimed at performance improvement as opposed to a blaming culture. In addition, the proper selection of utilising people, processes and technology are excellent ways to improve business performance. Last, illustrating the value of implemented learned lessons and rewarding people for using the system will ensure that individuals are keen on sustaining the system. Provided that leadership is aware and responsive to the aforementioned barriers, effective lessons learnt can be embedded into any organisation's practices.

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Is really local desert fill with fines content of more than 20% useless for the construction of an engineered fill? (an opinion on fill material shortage in the Kingdom of Bahrain)

SUMMARY

Recently in the Kingdom of Bahrain, there was a shortage in the supply of the desert fill material for grading works that can meet the specification of the Ministry of Housing (MoH) and the Ministry of Works (MoW), Kingdom of Bahrain. The main issue with the original material taken from the quarry in Hafeera is that, it will have fines content (portion passing 0.063mm sieve) which is mostly above 20%, which is more than the limit specified by the specifications. To meet the existing specifications, the material needs further treatment to reduce the fines content. Consequently, this treatment will cause an amplification in the cost of the construction works. The idea was raised to re-visit the existing specification in this case the Ministry of Housing's specification, to make a closer review to compare it with several research findings that support tthe use of material having fines more than 20% and to compare this existing specification with the practices in overseas and geotechnical engineering field of study. The purpose is to see if there is possibility of the use of this material having fines more than 20% without causing adverse effect on the performance of the engineered fill. The MoH's specification has limited the fill material to have maximum fines content of 20% and followed by the maximum Plasticity Index (PI) of 20%. The sulfate content and total soluble salt must be less than 1% and 2% respectively. The idea behind these values was to make sure that the small portion of this fines content will not cause adverse effect to the overall performance of the engineered fill. It is worried that if the soil is having fines more than 20% and PI of more than 20%, it is assumed it will weaken the engineered fill as well as will cause extreme volume change difference between dry and wet conditions. This will cause excessive settlement of the structures seated on this soil. Furthermore, the excessive settlement will cause damages to the structures. The extreme volume change during wet-dry cycle in the soil will happen only in certain soil that contains certain Clay mineral, which is called expansive Clay, which is mainly containing Montmorillonite/Smectite Clay. Most of the cases of cracks and damages of the structures built on this type of soil were caused by extreme volume change behaviour during wet-dry cycle. This type of clay will be soft when it is wet and extremely expanding and will shrink in extreme volume change when it is dry. The montmorillonite/smectite is formed mainly from volcanic ash and alkaline igneous rock. Certain clay-sized materials such as quartz and feldspar are not amongst the expansive ones which might be present in Bahrain soil. The swelling potential and activity of the fines component should be checked before rejecting the proposed material. In the countries such as Australia and Scotland, the engineering practitioners over there use the cohesive materials to form engineered fills. In conclusion, based on the literature study and engineering practices in overseas, the desert fill taken from Hafeera has a potential to be used as it is for grading works at MoH's sites. The MoH's specification needs to be reviewed and studied, to have more

1. Introduction :

The scarcity of the desert fill that could meet the technical specification of the Ministry of Housing or the Ministry of Works has become a National issue recently. The so called "good" desert fill shall not contain more than 20% fines in it, according to MoH's Specification. Is it really critical to impose a maximum fines of 20% in the Specification? Are the desert fills/materials containing more than 20% fines useless/unsuitable for making engineered fills?

This paper was prepared to give a different view in looking at the requirements of a good fill material by putting forward some arguments based on literature study, engineering practices in different countries on the use of material with more than 20% fines and some basic geotechnical engineering theories. The view would be used to propose for further detail studies on Bahrain local material to be used for the amendment of the existing MoH's specification, as well as for Bahrain National Standard in general for determining the acceptable materials to be used for the construction of the engineered fills.

2. Literature Review:

2.1. Bahrain Geological Condition

Bahrain's finer geo-materials are mainly found in the form of carbonate and siliceous Sand and silt/clay-size carbonate dominant material (weak siltstone), which are the products of the lengthy weathering process of different types of sedimentary rocks found in Bahrain such as Calcisiltite (Siltstone), Calcilutite (Mudstone), Calcarenite (Sandstone) and Limestone. Based on many chemical tests against the geo-materials found in Bahrain, the main component of these materials is Carbonate (CO3) that could reach up to 70% to 90%.

2.2. The Ministry of Housing Specification on Class 3 Material/Desert Fills :

Below table depicts the MoH's specification on the desert fill to be used at the MoH's sites.

Table 1. Typical grading envelope of Class 3 fills (Desert Fill) (Ministry of Housing - Kingdom of Bahrain, 2010)

Sieve size (mm)	% Passing
100	100
5	0 – 50
0.075	0 – 20

The specification (Ministry of Housing - Kingdom of Bahrain, 2010) says on page 4, that "….the desert fill (Class 3 Material) shall be selected, well graded, hard granular material free from clay and deleterious substances. The total sulfate content as SO3 of the material shall not exceed 1% and the total soluble salts shall not exceed 2%. The grading of the fill shall lie within the range as tested in accordance with BS 1377 Test 7. Where the percentage passing 0.075 mm sieve is greater than 8%, the Plasticity Index (PI) shall not exceed 20% when tested in accordance with BS 1377."

2.3. Effect of Fines on Engineered Fill's Performance :

The presence of certain fine material such as Clay will affect the overall performance of the engineered fill. The presence of certain Clay mineral can normally be detected by conducting an Atterberg Limit test against the sample of the material which is sieved against 0.425mm sieve according to BS Standard.

Different Clay minerals will behave in different manner. The main controlling factors are the main composition and chemical bond in the Clay mineral. The Montmorillonite clay will have different behavior compared to other Clay minerals, such as Kaolinite, Illite and Halloysite.

The activity (A) of the Clay minerals can be simply checked by using a formula by Skempton in 1953 (Holtz, R.D and Kovacs, W.D , 1981):

$$A = \frac{PI}{\%Clay\ Fraction}$$

The activity will show the capability of the clay mineral to absorb the surrounding water. The higher the Activity value the higher capability of the clay mineral to absorb water. This will affect its volume change behavior during dry-wet cycle. The Montmorillonite is the one which has very high Activity value, which is followed by its expansive behavior that will bring disadvantages to the structures built on top of it. The expansive clay will normally cause damages to the structures seated on it. Table 2 shows the activity values of different Clay minerals.

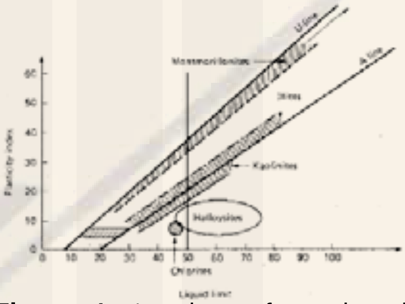

Figure 1. Locations of certain minerals in Casagrande's Plasticity Chart (Holtz, R.D and Kovacs, W.D , 1981)

Table 2. Activities of Various Minerals (Holtz, R.D and Kovacs, W.D , 1981)

Mineral	Activity
Na-montmorillonite	4-7
Ca-montmorillonite	15
Blite	0.5 - 13
Kaolinite	0.3 - 0.5
Halloysite (dehydrated)	0.5
Halloysite (hydrated)	0.1
Attapulgite	0.5 - 12
Allophane	0.5 - 12
Mica (muscovite)	0.2
Calcite	0.2
Quartz	0

*After Skempton (1953) and Mitebell (1976).

Table 3. Activities Classification Developed by Taylor in 1953 (Holtz, R.D and Kovacs, W.D , 1981)

No	Activity Value, A	Classification
1	<0.75	Inactive clays
2	0.75 – 1.25	Normal clays
3	>1.25	Active clays

The effect of the clay mineral in the proposed fill material should be checked whether it is from inactive, normal or active clays.

2.4. Typical Proctor CompactionTest Results of Different Materials

It can be seen from Fig 2 that most of the well graded granular materials showed good performance in terms of their final estimated maximum dry densities which were obtained from Proctor Compaction Tests at the laboratories.

The more fines content in the material the less the maximum dry density obtained. In addition to this fact, the uniform graded sand also showed the poor/lower maximum dry density.

The optimum water content in the materials have shown that the less fines content has the tendency to cause lower optimum moisture content. But, the case is completely different for the uniform graded sand which showed high optimum moisture content.

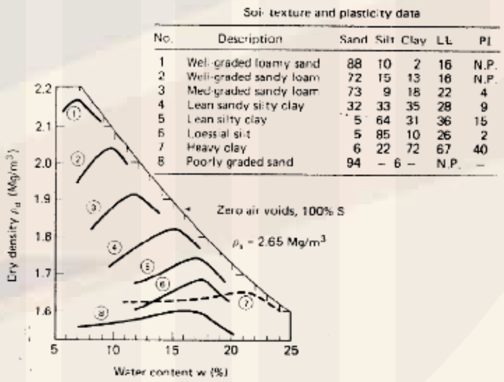

Figure 2. Typical Proctor Laboratory Compaction Curves for 8 different materials (Holtz, R.D and Kovacs, W.D , 1981)

According to Fig 2, sample No. 1 and 2 are sands that contain silt/clay of 12% and 28% respectively. These two samples achieved their maximum dry density of above 2.0 - 2.2t/m3. Sample 3 (sand), is with silt/clay of 27%, has achieved maximum dry density of around 1.9t/m3. Furthermore, the clay sample (No. 4) with 68% silt/clay and 32% sand, has reached maximum dry density of above 1.8t/m3. Based on this fact, the amount of silt/clay of more than 20% does not necessarily cause lower maximum dry density of the material..

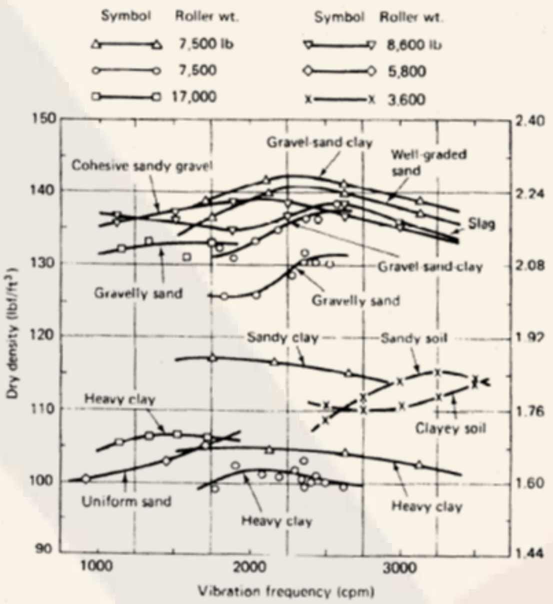

Figure 3. Field Densities Vs. Vibration Frequencies for different materials and compactive efforts (Holtz, R.D and Kovacs, W.D , 1981)

Figure 3. illustrates the relationship among the field dry densities obtained, compactive efforts and vibration frequencies applied at the sites where different fill materials were being used.

The materials mainly dominated by gravel and sand have shown high maximum dry densities obtained in the field which were compacted using vibrated rollers. The achieved densities are in the order of 2.08t/m3
 and 2.24t/m3

2.5. Earthworks Practices in different countrie

2.5.1. The Construction of Engineered Fills in Australia

There was an effort to reclaim a very deep ex mining pit situated in Sydney, New South Wales, Australia. It was completed on 22 July 2005, done for Enfield Brick Pit, which was more than 20m deep. One of the purposes of this reclamation works was to produce a landform which was suitable for medium density residential development immediately upon completion of filling at minimum cost. The materials used to reclaim this pit were Clay Fill and Sandstone Fill. The Clay fill was placed and compacted to 98% or greater of the results obtained from the Proctor Compaction Test in the laboratories. For Sandstone fill, it was placed and compacted to achieve in situ modulus of 40MPa as measured by Plate Load Test (PLT). The PLT was selected as field density test using sand cone or nuclear density apparatus was not applicable, as normal field density test using nuclear gauge will require certain material which has particles less than 20% retained on 37.5mm sieve (Piccolo, D and Mostyn, G, 2006).

In Sydney region, several materials are used for constructing the engineered fills. Some of them are soils derived from alluvial and residual deposits, which include silty and sandy clays (CL and CH), silty and clayey sands (SM and SC). Other materials are rock fill from sedimentary rocks consisting of gravelly, silty and clayey sands (SM and SC), gravelly, sandy and silty clays (CL) derived from sandstone and gravelly silty sand and sandy clays (CL and CH) derived from shale. One more material group that can be used for this purpose is recycled materials such as concrete, brickbats, clay pipe and tile, road materials including asphalt, road base and sub-base materials derived from quarried igneous materials (Waddell, P.J. and Wong, P.K., 2005).

2.5.2. Road works in Scotland

In Scotland, according to (Transport Scotland, 2015), the cohesive material (80% passing 0.063mm sieve) will be allowed to be used as backfill material for road construction.

Here is the quote of the roadwork standard issued by (Transport Scotland, 2015), depicted in Fig 4 below taken from page 50 of the standard which discussed the different type of materials which can be used for road works as well as the unacceptable materials description.

According to the above mentioned standard (Transport Scotland, 2015), the unacceptable materials will be as follows in Fig 5.

3. Proposed Detail of Geotechnical Analysis for Engineered Fill Material

To examine any proposed materials for constructing the engineered fills, Table 4 depicts some basic tests and standards to be used to judge the material before rejecting the materials.

4. Analysis and Discussions

4.1. Sieve Analyses Test Results

It can be seen that from Table 5, the material taken from Hafeera (Sample I) cannot meet the MoH's technical specification as the fines particles of this material is more than 20%. This material can be described as very silty, sandy GRAVEL with many cobble-sized rocks, according to (British Standard BS5930-1999, 1999). The material in average contained 28% Cobble, 30% Gravel, 12% Sand and 30% Silt/Clay (Material Engineering Directorate - Ministry of Works, 2015). On the other hand, the sample taken from the North Bahrain Offshore (Sample II) has been described as slightly sandy, slightly gravelly SILT/CLAY. Both samples cannot meet the MoH's specification.

S5.1 Backfill Material Classification

S5.1.1 **General**

Backfill materials, whether imported to site or derived on-site from excavated materials, shall be classified as follows:

S5.1.2 **Class A – Graded Granular Materials**

1) Materials with a maximum of 10% by mass passing a 63 micron (µm) BS sieve, and with all material passing a 425 micron (µm) BS sieve showing a plasticity index of 6 or less, determined in accordance with BS1377: Part 2: Method 5.4, are classified as Class A Graded Granular Materials.

2) Class A graded granular materials may include Granular Sub-base Material Type 2 to SHW Clause 804 (excluding natural sands and gravels) and Granular Sub-base Material Type 1 to SHW Clause 803.

S5.1.3 **Class B – Granular Materials**

Materials with a maximum of 10% by mass passing a 63 micron (µm) BS sieve are classified as Class B Granular Materials.

S5.1.4 **Class C – Cohesive/Granular Materials**

Mixtures of granular, silt and clay materials with between 10% and 80% by mass passing a 63 micron (µm) BS sieve are classified as Class C Cohesive/Granular Materials.

S5.1.5 **Class D – Cohesive Materials**

Clay, silt or mixtures of clay and silt with at least 80% by mass passing a 63 micron (µm) BS sieve are classified as Class D Cohesive Materials.

S5.1.6 **Class E – Unacceptable Materials**

Materials listed as unacceptable in paragraphs 2 ii) and 3 of SHW Clause 601 shall not be used, at any level, within the permanent structure of any reinstatement. Materials classified as unacceptable are listed in Appendix A1.

S5.1.7 The requirements of Appendix A1 shall apply to unbound backfill

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Figure 4. Different Types of Backfill and Unacceptable Materials (Transport Scotland, 2015)

A1.5 Class E – Unacceptable Materials

The following materials, listed as unacceptable in SHW Clause 601 paragraphs 2(ii) and 3, shall not be used at any level within the permanent structure of any reinstatement:

1) Peat and materials from swamps, marshes or bogs.
2) Logs, stumps and perishable materials.
3) Materials in a frozen condition. (Such materials, if otherwise suitable, shall be classified as suitable when unfrozen.)
4) Clays having a liquid limit exceeding 90, determined in accordance with BS1377: Part 2 Method 4, or a Plasticity Index exceeding 65, determined in accordance with BS1377: Part 2, Method 5.4.
5) Materials susceptible to spontaneous combustion.
6) Materials having hazardous chemical or physical properties requiring special measures for excavation, handling, storage, transportation, deposition and disposal.

Figure5. Further Description of Unacceptable Backfill Materials (Transport Scotland, 2015)

Table 4. Proposed detail tests for Fill Materia

No	Test	Results	Remarks
1.	Sieve Analysis and Hydrometer Test	Overall Particle Size Distribution of soil	☐ To see the material composition ☐ Making description ☐ To see the percentage of silt and clay fraction
2.	Atterberg Limit Test	LL, PL and PI	To see the plasticity index of material's portion passing 0.425mm sieve
3.	If percentage passing 0.063mm sieve more than 20%, do X-Ray Diffraction Test	Mineral composition	To see the presence of the expansive clay
4.	Proctor Lab Compaction, if the material portion passing sieve 37.5mm and 20mm are min 90% and 70%	Moisture-Dry Density Relationship Curve	To obtain the maximum dry density achieved and optimum moisture content
5.	To perform one of these tests, Plate Load Test or Large scale field density test or full scale zone load test for material fall in Grading zone X according to BS1377-1990 Part 4	Actual soil bearing capacity and actual soil field density	

4.2. Comparison of two completely different material taken from Bahrain territory

Table 5. Data comparison of two samples

No	Test/Parameters	Hafeera Sample (II)	North Bahrain - Offshore Sample (III)	Remarks
1.	Sieve Analysis -Description	very silty, sandy GRAVEL with many cobble-sized rocks	Slightly sandy, slightly gravelly SILT/CLAY	
2.	Silt/Clay Content	30%	93%	Sample II has more silt/clay than Sample I
3.	% Clay fraction	Unknown	45	
4.	LL - PL - PI	Unknown	57-35-22	Sample II Activity = PI% Clay = 22/45 = 0.48, considered inactive Clay
5.	X-Ray Diffraction	Not done	Not done	

Quote: "MoH's specification on desert fill will only accept material that contains fines of maximum 20%.......".

The logic behind the determination of maximum fines content of 20% is that, it is worried that if the materials having too much fines (> 20%), this will be followed by the higher plasticity index. When the materials component has PI of more than 20%, the materials will have instability towards dry-wet cycle The material will be swelling in significant volume expansion and will weaken the fill. In dry condition, the soil is predicted to have extreme volume change compared to when it is wet. This phenomenon will give disadvantages to the structures sitting on the soil, as this will damage the structures due to excessive settlement and loss of soil shear strength.

The higher PI value is normally caused by the higher percentage of the Clay-sized particles which is present in the materials proposed. The higher PI will normally be associated with a certain Clay mineral type. In certain case, one type of Clay minerals which has the extreme expansive behavior is Montmorillonite/Smectite, which is derived from volcanic ash and alkaline igneous rocks (Ladd, C.C, 1995). Based on the geological history of Bahrain, it is a fact that the geo-materials found in Bahrain are mainly rich with Carbonate (CO3). The rocks are mainly dominated by Mudstone (Calcilutite), Siltstone (Calcisiltite), Limestone and Sandstone, which are predominantly made from Carbonate. These rocks are the parents/origins of the finer materials like clay, silt and sand that might be found in Bahrain, from very long weathering process and vice versa. This carbonate-based material is not known to have expansive behavior. There was no solid proof reported in a comprehensive study published in any Journals or Geotechnical Conferences, that Bahrain geo-materials have the records of expansive behaviour. It is well understood amongst the Geotechnical Engineers across the globe that the presence of expansive clay might bring adverse effects against any structures seated on it. Since the desert fill will normally be taken from the same source (Hafeera), it is strongly suggested to verify the presence of the expansive Clay in the material, as relying on the limited sieve analysis and Atterberg limit test are not enough for the basis to reject the materials.

The fines content of more than 20% in a certain The logic behind the determination of maximum fines content of 20% is that, it is worried that if the materials having too much fines (> 20%), this will be followed by the higher plasticity index. When the materials component has PI of more than 20%, the materials will have instability towards dry-wet cycle The material will be swelling in significant volume expansion and will weaken the fill. In dry condition, the soil is predicted to have extreme volume change compared to when it is wet. This phenomenon will give disadvantages to the structures sitting on the soil, as this will damage the structures due to excessive settlement and loss of soil shear strength.

The higher PI value is normally caused by the higher percentage of the Clay-sized particles which is present in the materials proposed. The higher PI will normally be associated with a certain Clay mineral type. In certain case, one type of Clay minerals which has the extreme expansive behavior is Montmorillonite/Smectite, which is derived from volcanic ash and alkaline igneous rocks

(Ladd, C.C, 1995). Based on the geological history of Bahrain, it is a fact that the geo-materials found in Bahrain are mainly rich with Carbonate (CO3). The rocks are mainly dominated by Mudstone (Calcilutite), Siltstone (Calcisiltite), Limestone and Sandstone, which are predominantly made from Carbonate. These rocks are the parents/origins of the finer materials like clay, silt and sand that might be found in Bahrain, from very long weathering process and vice versa. This carbonate-based material is not known to have expansive behavior. There was no solid proof reported in a comprehensive study published in any Journals or Geotechnical Conferences, that Bahrain geo-materials have the records of expansive behaviour. It is well understood amongst the Geotechnical Engineers across the globe that the presence of expansive clay might bring adverse effects against any structures seated on it. Since the desert fill will normally be taken from the same source (Hafeera), it is strongly suggested to verify the presence of the expansive Clay in the material, as relying on the limited sieve analysis and Atterberg limit test are not enough for the basis to reject the materials.

The fines content of more than 20% in a certain material does not necessarily will cause bad effect on the performance of the engineered fill. Further solid and sound data are required as the basis to reject the materials. Fig 2 has shown the argument which is against the MoH's specification, the sands with silt/clay content of **28% and 27%** managed to achieve quite high maximum dry densities, which are in the range between 1.9t/m3 and 2t/m3. The maximum dry density of around 2t/m3 can be empirically translated to the N-SPT (Standard Penetration Test Blows Number) of 30-40 and an internal friction angle of 33o-34o (Gunaratne, M, 2006). With these soil shear strength properties, the soil has an indication of having much more greater bearing capacity than the structural loads imposed to the ground by typical T3 or T8 House Type according to MoH's house standard. The typical structural load of around 60kPa is generated by these type of houses.

Another example of the use of material having more than 20% fines was the construction of a deep engineered fill that was constructed in Sydney in 2005. A detail story on the construction method and engineering calculation was beautifully documented in (Piccolo, D and Mostyn, G, 2006). In this project, Clay fill and sandstone were used to construct this fill.

Further example on this issue is the finding of silt/clay below the sea bed in the North Bahrain Offshore Site. The geotechnical investigation was carried out to investigate the ground condition beneath the sea floor at the reclamation site situated in the sea at the Northern side of Bahrain Island. The sample physical properties data were depicted in the above table 5. It was taken from the depth of 3.5m below the seabed. The sieve analysis revealed that the percentage particles passing 0.063mm sieve was around 93%, which is the indication that this material is dominated by silt/clay. Based on the hydrometer test, the silt and clay-sized particles percentages are 48% and 45% respectively. The field N-SPT test was carried out at this sample's location below the seabed at the site, resulting N-SPT blows of 19 (very stiff clay). The Atterberg Limit test was conducted against this sample and revealed LL=57; PL=35 and PI=22. Based on formula (1), the Activity value is **22/45 = 0.48.** The activity value shows the indication of water absorption capability of the clay-sized particle's surface. The greater the value of the activity will bring the consequence that the material will have high capacity to absorb more water and having high swelling potential. The silt/clay material in this discussion is classified as **inactive clays**, as the Activity value is only 0.48. Most likely there was no trace of typical expansive clays in this sample. In terms of the strength parameters, the initial N-SPT of this material was 19, which is a typical characteristics of quite strong clay, this SPT value can be translated to the undrained shear strength of 200-400kPa. The soil has good ultimate bearing capacity of roughly 500kPa. Even though this soil is composed mainly by silt/clay particles, since it was well deposited, compressed and consolidated, it has high bearing capacity.

The lesson learned from this phenomenon, even though the material is dominated by 93% of fine particles passing 0.063mm sieve, the material does not show the tendency to behave as expansive soil and does not show a typical weak soil characteristics. Its activity value is within inactive clays. From here it can be said that it is not always possible to conclude that all materials having description of Silt/Clay found in Bahrain will always have expansive behavior and considered as weak soil. From this exercise, it can be predicted that the clay mineral in this material is not typical expansive one, like Montmorillonite (Al3.3Mg0.7)[Si8]O20(OH)4. There might be other clay mineral or different material which has similar size like clay. Surprisingly, the particles of quartz (SiO2), feldspar (KAlSi3O8) or mica are small enough and having sizes that fall within the clay classification (Das, B.M, 2006). Furthermore, the presence of other clay-sized material, made of quartz and carbonate might "dilute" the expansive behaviour of clay (Mokhtari, M. and Dehghani, M., 2012).

From this limited study, in comparison, the Hafeera sample is not dominated by silt/clay, instead, it is consisting of 70% material within sand, gravel and cobble-sized particles. It is quite hard to imagine that the small portion of silt/clay will dictate the overall engineering behavior of this material. However, further examination using advanced technology is required to have detail and comprehensive studies on the material proposed for backfill material taken from Hafeera.

4.3.2. Material with Plasticity Index of more than 20% is rejected

Quote : "MoH's specification dictates that any material for desert fill with fines content of more than 8%, shall have maximum Plasticity Index of 20…."

The engineering practitioners in overseas such as in Australia and Scotland for example, they use even Clay Soil for making an engineered fill.

In Australia, as elaborated in detail in (Waddell, P.J. and Wong, P.K., 2005), some soils derived from alluvial and residual deposits, which include silty and sandy clays (CL and CH), silty and clayey sands (SM and SC) were used for the construction of an engineered fill. Other materials are rock fill from sedimentary rocks consisting of gravelly, silty and clayey sands (SM and SC), gravelly, sandy and silty clays (CL) derived from sandstone and gravelly silty sand and sandy clays (CL and CH) derived from shale. One more material group that can be used for this purpose is recycled materials such as concrete, brickbats, clay pipe and tile, road materials including asphalt, road base and sub-base materials derived from quarried igneous materials.

In Scotland, there are certain unacceptable materials that will be rejected to be used as backfill materials, one of them is **Clay with Liquid Limit (LL) of higher than 90% or having Plasticity Index (PI) of higher than 65%** (Transport Scotland, 2015). Any proposed materials having less values in liquid limit and plasticity index than 90% and 65% will be acceptable for this purpose.

The material taken from Hafeera site in this discussion seemed to have better condition in comparison with the fill material which may be used in Scotland and Australia. Based on the sieve analyses results of the material taken from Hafeera, the PI value is predicted to be quite low, as when the sample will be prepared for testing, the sand component will be included as per BS Standard test (British Standard BS1377-1990 Part. 2, 1990). The required sample must be sieved through 0.425mm sieve. The sand component will reduce the plasticity logically.

4.3.3. Quality control on compacted desert fill at MoH's sites

The silt/clay material in this discussion is classified as The inappropriate practice in controlling the fill quality at the MoH's sites have been seen and observed. The material like desert fill in Bahrain are predominantly formed by large quantity of oversized material (gravel/cobble-sized limestone/siltstone), due to this condition, certain method for checking the fill quality cannot be used (Proctor Compaction Tests and Field Density Test using sand cone or nuclear gauge), but yet the method is still being adopted at the sites. The current practice is unacceptable according to either BS Standard (British Standard BS1377-1990 Part 4, 1990) or ASTM (ASTM D1557 - 09, 2009), this matter has been elaborated and discussed in (Utomo, P, 2014).

4.3.4. Concluding Remarks on MoH's specification

In the light of the above discussions and several proofs from different resources, there is a great possibility that the fill material with more than 20% fines can be used for making an engineered fill without causing bad effect to the engineered fill's performance. The MoH's specification could be amended by considering the results of further detail study on the Hafeera Material or material with fines more than 20%. The study could include: further mineralogy investigation using X-ray diffraction, carrying out a full scale loading test (actual soil bearing capacity) and full scale density test against the laid fill (actual field density achieved). Moreover, the detail investigation on the desert fill material that already laid in the past at the MoH's sites needs to be conducted as well, to evaluate its performance and to trace the possibilities on the use of desert fill containing fines more than 20%.

4.4 Brief Story on Expansive Clays in Middle East

Recently in the year 2012, there was study conducted by Saudi Arabia's Researchers on expansive clay in semi-arid region, which was carried out in Saudi Arabia region (Daffala, M.A. and Shamrani, M.A., 2012). It was concluded from this research, that certain areas, especially Hofuf, which is the nearest point to Bahrain Island, the research team found the expansive clays. The study on the physical properties of these clays were done and all of the samples showed the similar or same description according to Unified Soil Classification System (USCS), such as CL (Clay with Low Plasticity), CH (Clay with High Plasticity), ML (Silt with Low Plasticity) and MH (Silt with High Plasticity). According to USCS system, if the percentage of the sample passing sieve No. 200 is more than 50%, this will be classified to be silt (M), clay (C) or Organic (Pt). The second letter will come after the Atterberg limit test is done to find the value of PI based on the Plasticity chart developed by Casagrande (Figure 1). The study revealed that based on several X-ray diffraction tests, there was the indication of the presence of expansive clay minerals belonging to Smectite group in all samples tested. In their conclusion, this Saudi-based study was conducted against the samples which are the real Clays and also proven to be amongst the expanding minerals and not a study on effect of the clays presence in the gravel or sand-sized dominant materials.

5. Conclusions and Recommendations

5.1. Conclusions

Based on very limited data and the literature review from different resources, several conclusions can be drawn as follows:

1 The desert fill sample (Sample I) taken for testing showed the indication that it failed to meet the existing MoH's specification due to its fines content which was around 30%. This is above the MoH's specification which limits the fines content for up to maximum 20%.

2. The material's fines content of more than 20% will not always cause adverse effect to the engineered fill, according to literature studies, research has shown that sands with 28% silt/clay can achieve high maximum dry density of 2t/m3. Furthermore, even engineers in overseas use cohesive material/clay for constructing the engineered fills. Based on these facts, there is possibility/chance for Hafeera material to be used for grading works at MoH sites.

3. There is hidden potential from this desert fill recently taken from Hafeera to have maximum dry density of above 2t/m3 as this is dominated by 70% sand, gravel and cobble-sized rocks which will give quite high bearing capacity.

4. Bahrain offshore soil sample consisted of 93% of fines, has been studied and examined. It revealed the indication that this silt/clay is the inactive one. Logically, the material like desert fill from Hafeera is dominated by 70% sand, gravel and cobble, it will most likely have better properties that will not indicate the signs of the active clay with high swelling potential.

5.2. Recommendations

1 The MoH's specification related to earthworks should be reviewed and amended based on careful studies conducted on Bahrain materials and condition as well as by considering other's earthworks practices in different countries.

2. The desert fill stock pile like in this discussion can be used for grading work at MoH sites, however further detail studies are required such as:

- using X-ray diffraction test to study the mineral composition
- to increase the sample frequency and number
- to perform more detail sieve analyses included hydrometer tests and swelling test.

3. To re-visit and re-examine the existing completed housing sites that used desert fill to review the performance of the materials used. As there might be materials having more than 20% fines content used at the sites.

4. To invite the authorities in Bahrain who are equipped with advanced geotechnical laboratory such as the researchers at the University of Bahrain and the Ministry of Works to form a team to conduct a comprehensive study/research to find a solution on the use of local desert fill as it is for local construction projects.

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Basecamp Article

Today's world is all about collaboration and immediacy. The internet bridged gaps in ways we could not imagine. Todya's project manager is now required to respond immediately to Clients, Stakeholders, and his team. He needs to be organized and keep everyone informed. How can today's project manager manage assigning tasks, continuous team dialogue, and working files? There are many online products that provide such facilities, depending on the complexity of the project. One of such platforms is Basecamp.

Basecamp is a collaborative platform that allows teams to collaborate on projects. Millions of users depend on basecamp for the collaboration activities including famously Adidas, NASA, and Nike. Basecamp's interface is considered very user-friendly. While Basecamp is considered simpler than other collaborative project management platforms (such as Asana), it's hardly lacking in features. Its simplicity is what makes it efficient and easy to use. Here's what you can do with Basecamp:

A. Set-up individual projects and invite team members and clients for specific projects.

B. Once projects are set up, you can access the project's main page, where you can see all the updates, activities, and to-do lists.

C. Create to-do lists and assign members with deadlines accordingly.

D. Create text documents that members can review and edit

E. Upload files for the team members to view.

F. Hold discussions within the project camp and comment on items (tasks, text documents, or files).

Basecamp is not only available online, and accessible by any computer, it is also available across all platforms (iOS and Android). Third-party apps that integrate with Basecamp can also enhance the experience.

For more information and to sign up for 12 months free, please visit: basecamp.com.bh

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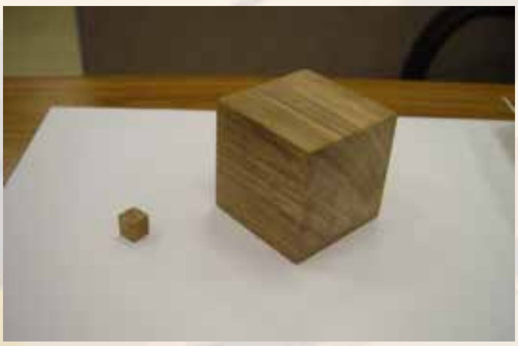
"Repair and Cathodic Protection of Sea Water Intake Concrete Structure"

•Introduction

Due to the sever environment in GPIC especially at the SWI area, i.e. high salinity, high humidity and high temperatures, the concrete structure had suffered from damage by cracking and delamination due to reinforcement corrosion.

Delamination is the formation of a separation layer between the reinforcing steel and the concrete due to the formation of corrosion products. When the bond is lost between concrete and steel, the structural integrity is put into jeopardy.

These corrosion products occupy from 2 to 6 times the volume of the original steel. This volume increase puts tremendous tensile stresses on the concrete, and when these stresses exceeds the tensile strength of the concrete, cracking develops.

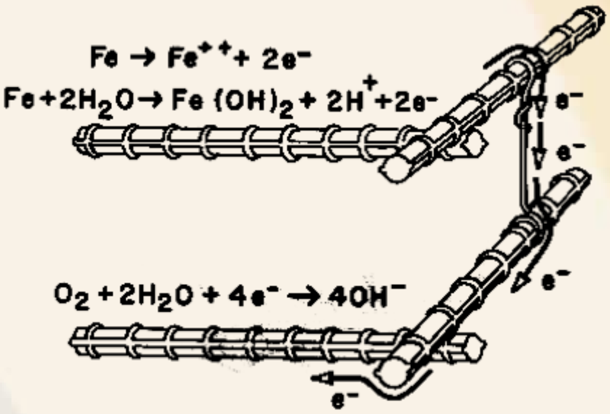


What is Corrosion ?

- Concrete is a mixture of cement, water, aggregates (fine and coarse) and admixtures. Cement is the binding material which in reaction with water forms products of hydration known as C-S-H and lime $Ca(OH)2$.
- The strongly Alkaline nature of $Ca(OH)2$ (PH=13) prevent the corrosion of steel reinforcement by the formation of a thin protective film of iron oxide on the metal surface, this protection is known as passivity. When passivity is destroyed corrosion will take place provided other factors exist. The passive film can be destroyed by either loss of Alkalinity by carbonation or by Chloride ions which have the ability to destroy the passive film even at high Alkalinities.

A Brief Description of the Corrosion Process

- When there exists a difference in electrical potential along the steel bar, an electrochemical cell is setup consisting of an anode and a cathode connected by the electrolyte which is the pore water. The positively charged Ferrous ions Fe^{++} at the Anode pass into solution while the negatively charged free electrons e^- pass through the steel into the cathode where they are absorbed by the constituents of the electrolyte and combine with water and oxygen to form hydroxyl ions $(OH)^-$. These travel through the electrolyte and combine with the Ferrous ions to form Ferric Hydroxide which is converted by further oxidation to rust.



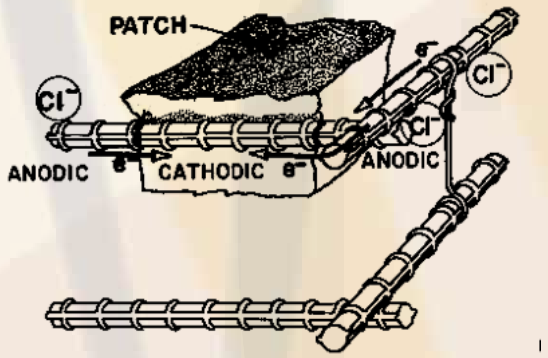
- A site investigation was carried out at the SWI concrete structure to find what was the main reason of steel corrosion; carbonation or chloride contamination.
- Site tests and sampling to determine the depth of carbonation and chloride content were done and the results are shown in the following table.

Risk of Corrosion	Total chloride content (acid soluble) in the concrete as % of chloride ions by weight of oven dried mass
Low risk	< 0.06 %
Depends on circumstances	0.06 - 0.08 %
High Risk	> 0.08 %

Location 4 - Sea water basin wall, 2m from top of wall (tidal zone)	0-50	0.12
	50-100	0.05
	100-150	0.05
	150-200	0.02
Location 6 - Top surface of slab at east end of Sea Water Intake area	0-50	0.17
	50-100	0.06
	100-150	0.07
	150-200	0.04
Location 7 - Vertical surface of sea wall, 1.5m from top of wall	0-50	0.14
	50-100	0.09
	100-150	0.07
	100-150	0.07
	150-200	0.05
Location 8 - Vertical surface of sleepers at Chlorine Plant	0.50	0.04
	50-100	0.03
	100-150	0.03
	150-200	0.03

Repair Options

- Patch repair: A common practice of concrete repair is to remove the delaminated concrete and patch the area with new chloride free concrete. With time, it became apparent that this type of patching was a never-ending process. From the corrosion mechanism, strong electrochemical macrocells are established near the interface between the old chloride-contaminated concrete and the new chloride-free concrete. The chloride concentration result in strong potential gradients which accelerate corrosion. In many cases this kind of repair will require rehabilitation again in one or two years.

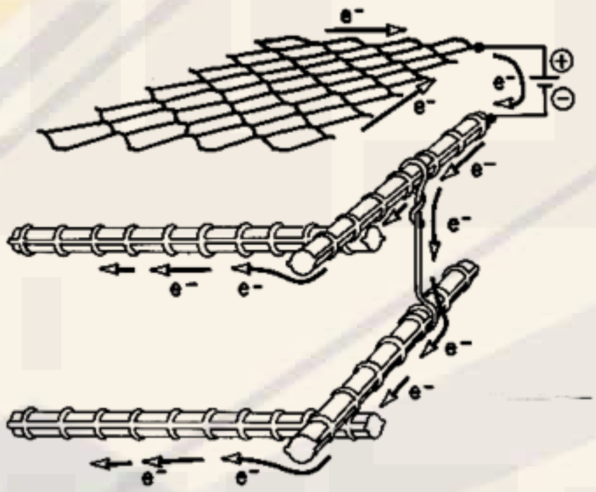


- Membranes, Sealers, Corrosion Inhibitors and Coated Rebars: This includes the use of passive barrier systems such as coatings on the steel and the concrete and modifiers to the concrete mix. The principal of these systems is to place an inert barrier between the reinforcement and the environment in an attempt to prevent interaction between the two. The degree to which these techniques have been successful has largely been dictated by the quality of the applied material and more importantly, they are frequently subject to damage during application. All of which negate their usefulness.

- Being passive systems, there is no way of knowing that they have failed until such time as the concrete is damaged and by then it is almost to late to do anything except start a large and expensive repair program.

Cathodic Protection

- As described earlier the corrosion of a metal is a result of an electrical current flowing from one part of the metal (anode) to the other (cathode), and the corrosion occurs where the current leaves the steel (at the anode).
- Cathodic Protection uses electrochemical techniques to ensure that oxidation reactions (production of electrons) do not occur at the reinforcing steel. This is accomplished by adding a supplemental anode to the system which is capable of sustaining oxidation reactions without suffering any physical damage. When such an anode is connected to the positive terminal of a power supply, and when the reinforcing steel within the concrete is connected to the negative terminal, the entire reinforcing cage is forced to become cathodic.
- Therefore, if all the anode sites were forced to function as current-receiving cathodes, then the entire metallic structure would be a cathode and corrosion would be eliminated even at high concentrations of Chloride ions.



- All delaminated concrete was repaired using patch repair method. In badly delaminated areas, like the slab supporting the sand pumps in the basins the whole slab was demolished and recasted. Patch repair is required to:
- Achieve Electrolyte Continuity: Cathodic Protection current will not cross air gaps so all delaminations and cracks must be repaired.
- Ensure structural reliability.
- An ICCP, Impressed Current Cathodic Protection system with MMO (Mixed Metal Oxide) coated Titanium Anode Ribbons were designed for the areas above water level.
- For the deck slab and walls the Anodes were embedded in slots. The size of the slot is 6mm wide by 25mm deep.
- The slots were cut using an asphalt cutter or by the grinder.
- On the slab the slot is vertical while on the wall it is inclined to approximately 45 deg to make it easier to grout the anode.
- The Anodes were grouted using a non-polymer grout in a fluid consistency to ensure the full encapsulation of the Anodes.

Conclusion

As a conclusion, the following points can be raised:

- Significant deterioration of reinforced concrete is likely to occur in the Gulf marine tidal, splash and airborne zones.
- Concrete in a Petrochemical Complex has an important role as it is constructed to give rigid supports for all of its machines and equipment.
- Deterioration or failure of it should be eliminated as it will lead to considerable losses in the income and profit due to the shutdown of the complex plants partially or totally.
- Mixed Metal Oxide (MMO) coated Titanium Anode Ribbons are an appropriate choice for application of Cathodic Protection to steel reinforced concrete deck or wall structure.
- Maintenance free structures up to 25 years can be achieved using Cathodic Protection.

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Industrial Gases Market in Bahrain

Introduction

It is true that air which is the main feedstock for the production of industrial gases doesn't cost producers anything and is absolutely free. However, among many other processes, air needs to be cooled cryogenically which is an energy-intensive process. For a world-scale air separation units (ASU), it is estimated that around 0.504 KWh[1] is consumed for each ton of oxygen. That is why industrial gases producers actually sell energy and not just the free air.

Key gases produced from ASU include oxygen, nitrogen and argon. There is a wide range of applications for these air gases. Oxygen is used in chemical processing, glass manufacturing, health care, metal fabrication and production, steel manufacturing and water treatment. Nitrogen, on the other hand, is used in chemical processing, concrete cooling, electronics, food, oil refining, glass manufacturing and metal manufacturing. Argon is used in metal processing and manufacturing, electronics and other applications.

In addition to the main gases like oxygen, nitrogen, and argon, there is a wide spectrum of gases produced from other sources including carbon dioxide (CO2), hydrogen (H2), acetylene, helium, specialty gases and many others gases. For example, CO2 is used in carbonated drinks, welding gases, dry ice production, fire extinguishers and production of chemicals.

Historically, industrial gases market in Bahrain, and GCC has been centered around oligopoly which is a situation where a small number of companies are active in the market with limited competition.

In this article, the market dynamics of industrial gases in Bahrain are discussed in a high level.

Bahrain Market

A few years ago and before the entry of the international players in the Bahraini market, industrial gases industry has been dominated by two local producers, Yateem oxygen and Bahrain Medical and Industrial Gases Plants (BMIGP). At present, Praxair, an international American-based company, controls the market in Bahrain after the acquisition of BMIGP as well as after acquiring a stake in Yateem Oxygen.[2] Praxair started up its 350 tons per day air separation unit for the SULB project in Hid in 2013. [3]In comparison with Yateem's and BMIGP's ASUs, Praxair has a more efficient plant benefited from the economy of scale and advanced technology.

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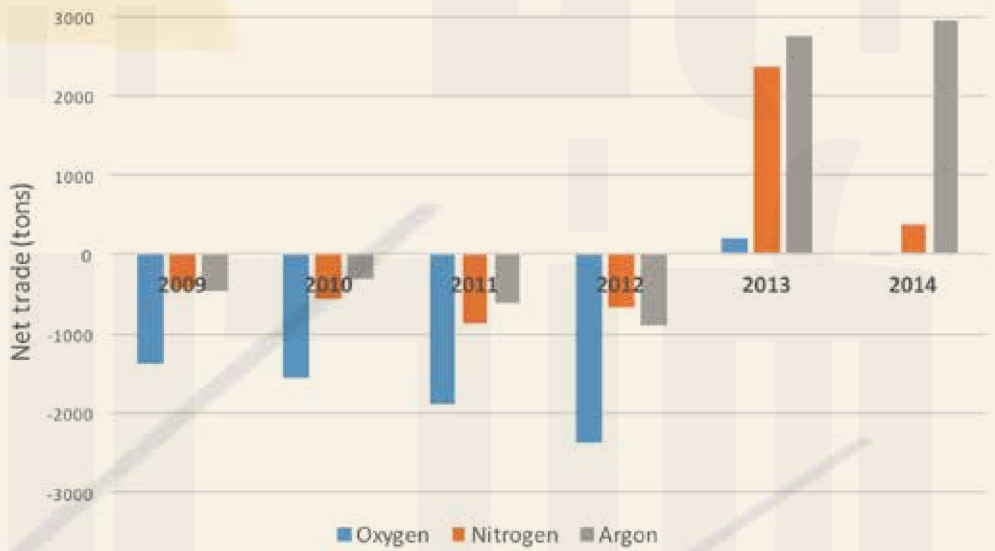
[1]Cost of production model obtained from a non-confidential project handled by the author.
[2]Commercial registration records of the Ministry of Industry and Commerce, Bahrain.
[3]Praxair's website: http://www.praxair.com/news/2013/praxair-starts-up-first-air-separation-unit-bahrain

As Figure 1 shows, Bahrain was a net importer of oxygen, nitrogen and argon. However, since Praxair started up its ASU in 2013, Bahrain turned to a net exporting position. Oxygen is mainly used for the SULB project and medical sector and the rest of ASU products are sold in the domestic market with the surplus being exported to the neighboring countries.

Figure 1. Bahrain Net Trade of Oxygen, Nitrogen and Argon[4]



Furthermore, Air Liquide, which is an international French-based company, has a controlling stake in the CO^2 recovery plant built adjacent to the Refinery in Sitra.[5] This plant which has a nameplate capacity of 200 tons a day was originally initiated by Yateem Oxygen with the support of Bapco.[6] Air Liquide, at a later stage, acquired a controlling stake of this project which started up a couple of years ago. Bapco provides a carbon dioxide-rich feed stream from the Refinery's No.1 Hydrogen Plant which used to be vented to the atmosphere.[7] In Bahrain, CO^2 used to be produced by the combustion of kerosene or diesel which are valuable fuels. As a result, this project is considered environmentally and economically attractive. Gulf Petrochemical Industries Company (GPIC) opened the door for such an efficient use of CO^2 in Bahrain through its Carbon Dioxide Recovery (CDR) plant which started up in 2010. GPIC's CDR has a capacity of 450 tons a day and CO^2 is used captively to boost methanol and urea production.[8]

Bahrain has been a net exporter of CO^2 with relatively small volumes of export, as illustrated by Figure 2. However, in 2014, the CO^2 export witnessed a sharp increase due to the commissioning of the new CO^2 recovery plant at the refinery in Sitra.

[4]Comtrade database
[5]Airliquide's website: https://www.airliquide.com/bahrain
[6]The author was involved in the planning phase of the CO_2 recovery.
[7]The Islander page 5, published on 1st March 2014 by Bapco.
[8]GPIC's website: http://www.gpic.com/responcibility/CDRmoved/ImplementingCDRMilestones/ImplementingCDRMilestones.aspx

Figure 2. Bahrain Net Trade of Carbon Dioxide[9]

The market of nitrogen, argon and carbon dioxide in Bahrain is clearly in over-supply situation and the need for export is necessary. Oxygen market looks balanced with the current demand for steel and medical sector.

Hydrogen is another important gas. Worldwide, hydrogen is used in oil refining, petrochemicals and chemicals production, fuel cells, power plants as coolant, production of vegetable oil, float glass, steel production and electronics. Due to the hazardous nature of hydrogen, it is typically produced and used at site or transported via pipelines. In Bahrain, the key end uses for hydrogen are refinery hydro-treating and hydrodesulphurization processes and ammonia production.[10] Hydrogen in Bahrain is used in a much smaller scale as a coolant for power plants. It is worthwhile pointing out that the production of methanol requires large volumes of hydrogen but in the form of syngas which is a mixture of carbon mono-oxide and hydrogen.

Table 1 shows the main uses of hydrogen in Bahrain with a high-level estimation of demand.

[9]Comtrade database
[10]Primary research carried out by the author.

Table 1. Main Hydrogen Producer/Consumer, 2014

Company	Hydrogen end use	Estimated Hydrogen Consumption (MMSCFD)
Bapco [11]	Hydrodesulphurization (refiining)	164
GPIC [12]	Ammonia production	82

As with other industrial gases, hydrogen has potential uses in Bahrain which are currently not existing. For example, in GCC there are more industries that utilize hydrogen as Table 2 illustrates.

Table 2. Other significant uses of hydrogen in GCC (other than oil refining and Ammonia production)[13]

Country	Company	Hydrogen end use
KSA	Saudi Chevron Phillips	Cyclohexane production
KSA	Cristal	Hydrogen peroxide production
KSA	Saudi Hydrogen Peroxide Company	Hydrogen peroxide production
Qatar	Qatar Solar Technologies (QSTech),	Polysilicon production
KSA	IDEA Polysilicon Company	Polysilicon production
KSA	Polysilicon Technology Company (PTC)	Polysilicon production
KSA/UAE	UFG Obeikan Glass Company GulfGuard Emirates Float Glass Guardian Zoujaj International Float Glass	Float glass process
UAE	Emirates Refining Company (IFFCO) United Foods Company (PSC)	Vegetable oil
KSA/UAE/Qatar	Limited number of companies	Steel DRI process
All GCC	Power plants	Collant

Conclusion

The growth of the industrial gases market in Bahrain has been high due to the major projects which were commissioned in the country. However, the market is expected to have a much lower growth rate during the next few years as industrial gases market will be driven mainly by the existing industries like oil refining, steel production, other manufacturing, carbonated beverages and medical sector.

The market of nitrogen, argon and carbon dioxide in Bahrain is clearly in over-supply situation and the need for export is necessary. Oxygen market looks balanced with the current demand for steel and medical sector.

There is untapped potential for some gases in Bahrain including hydrogen which can be used for the production of chemicals, float glass, vegetable oil or even the emerging market in automotive fuel.

[11]Based on published data for the capacity of Bapco's hydrogen plant. 100% operating rate is assumed

[12]Based on ammonia capacity of 396 thousand tpa, stoichiometric proportions and 100% operating rate are assumed.

[13]Primary research carried out by the author.

End of article.
December 2015.

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