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Assessment of Causes of Damage due To Awaran Earthquake 2013

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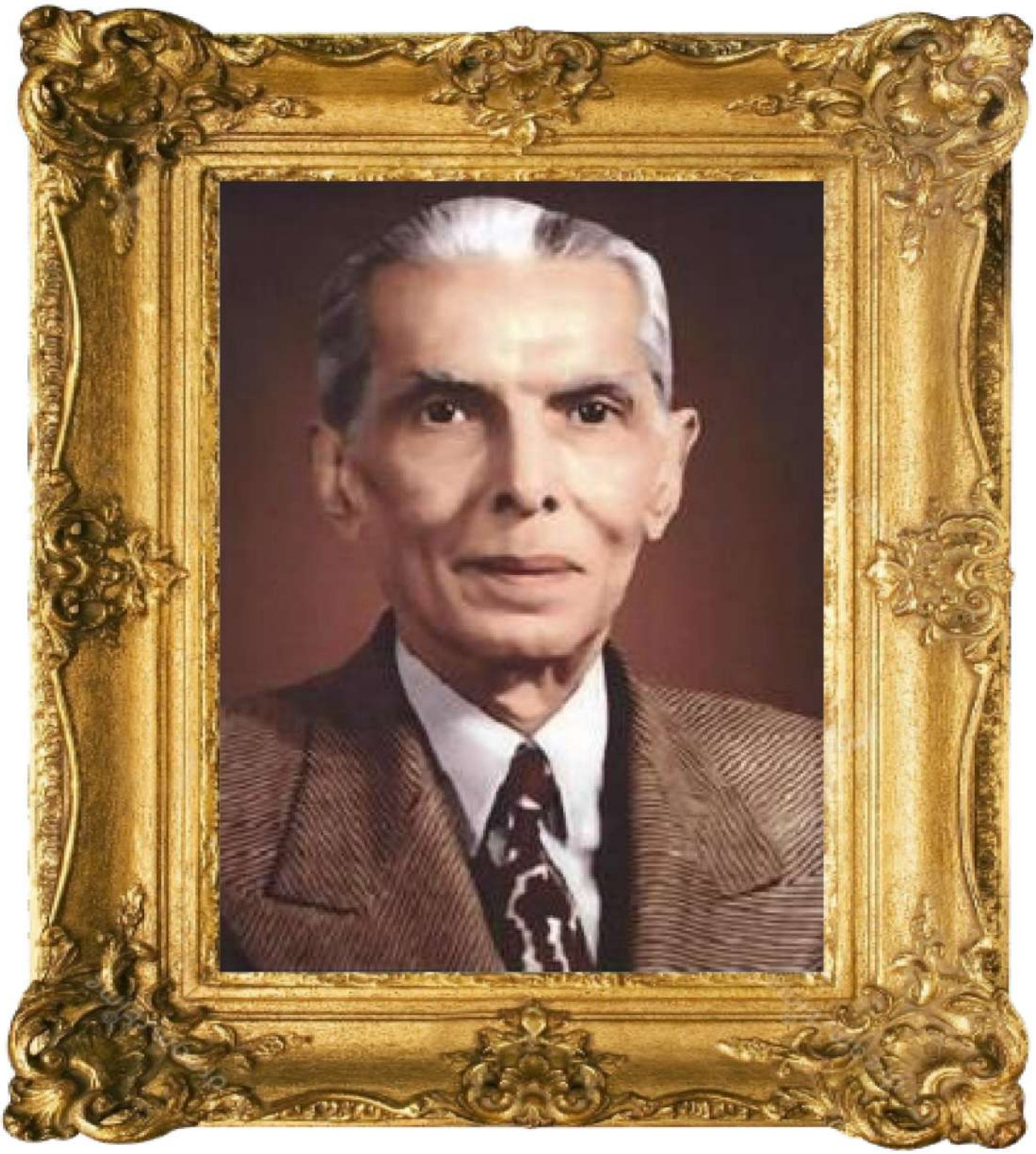

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I wish the Institute every success".

(Quaid-e-Azam's message to the first inaugural meeting of the Institute of Engineers on 20th June 1948)

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Assessment of Causes of Damage due To Awaran Earthquake 2013

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ABSTRACT
A survey was conducted by the Balochistan University of Information Technology, Engineering and Management Sciences of the areas affected by the recent earthquake in Awaran. The survey was primarily focused on the assessment of the prevailing construction materials and construction techniques and the factors that contributed to the damages of such a scale. It is expected that the findings will be helpful in making engineering intervention in order to avoid excessive damage in case a future disaster strikes the area. This paper presents a compilation of the survey report along with the causes of damage that were identified.

Keywords: Awaran Earthquake, Damage Assessment, Field Survey, Construction Techniques.

INTRODUCTION

On the 24th September, 2013, a strong earthquake of magnitude 7.7 on the Richter scale hit the Awaran district, the epicentre of which is shown in Figure 1. The earthquake caused enormous damage. Thanks to Almighty, the loss of life was not proportionate to the magnitude of the earthquake. This was because of the time of the earthquake, which was about 4:30 in the afternoon, a time when most of the people were outside their homes. The devastation caused to the structures was, however, of the unimaginable scale. Entire villages and towns were turned into piles of debris. The scale and magnitude of the destruction was known only a few days after the earthquake when reports started appearing on the media. In some areas of Mashke Tehsil, the destruction could be measured up to XII on Marcelli scale.

As per the information provided by the United States Geological Survey, "the earthquake occurred on 24th September at 11:29 UTC, 16:29 local time. The epicenter was located at 26.951 ºN and 65.501 ºE, which translates into 61 Km NNE from Awaran city and about 270 Km N of Karachi."

According to the USGS, "the earthquake was a result of oblique-strike-slip type motion at shallow crustal depths as the epicenter depth was estimated at about 15 Km. The location and mechanism of the earthquake are consistent with rupture within the Eurasia plate above the Makran subduction zone. The event occurred within the transition zone between northward subduction of the Arabia plate beneath the Eurasia plate and northward collision of the India plate with the Eurasia plate."

GEOGRAPHIC TERRAIN AND HISTORY OF EARTHQUAKES

Awaran district is located in the central Balochistan province. It is one of the largest districts of Pakistan with its border touching Khuzdar in the north, Bela in the east, Ormara in the south and Panjgur in the west. When looked at via satellite as shown in Figure

2, it is evident that the entire district consists of wide valleys running continuously southward serving as a conduit for the rainwater from the mountains to the Arabian sea. It would have been a large river bed had there been any glaciers on the upstream. In the present condition the area remains dry save for the rainy season, which is the chief source of water for the area. The southernmost and northernmost edges of Awaran district are approximately 350 Km apart.

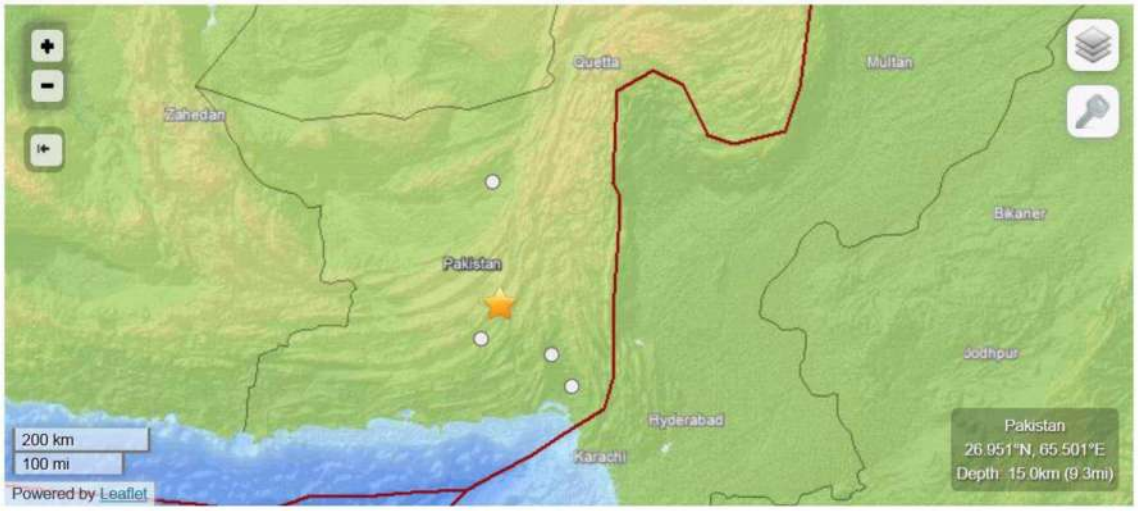

Figure 1: Epicenter of the recent earthquake in Awaran (source: www.usgs.gov)

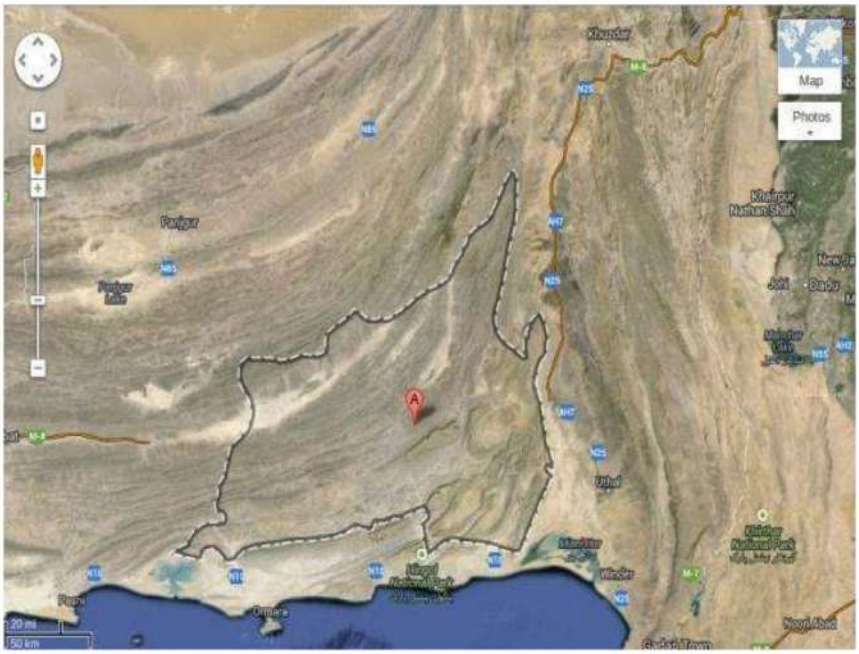

Figure 2: A satellite image of Awaran district (source: www.maps.google.com)

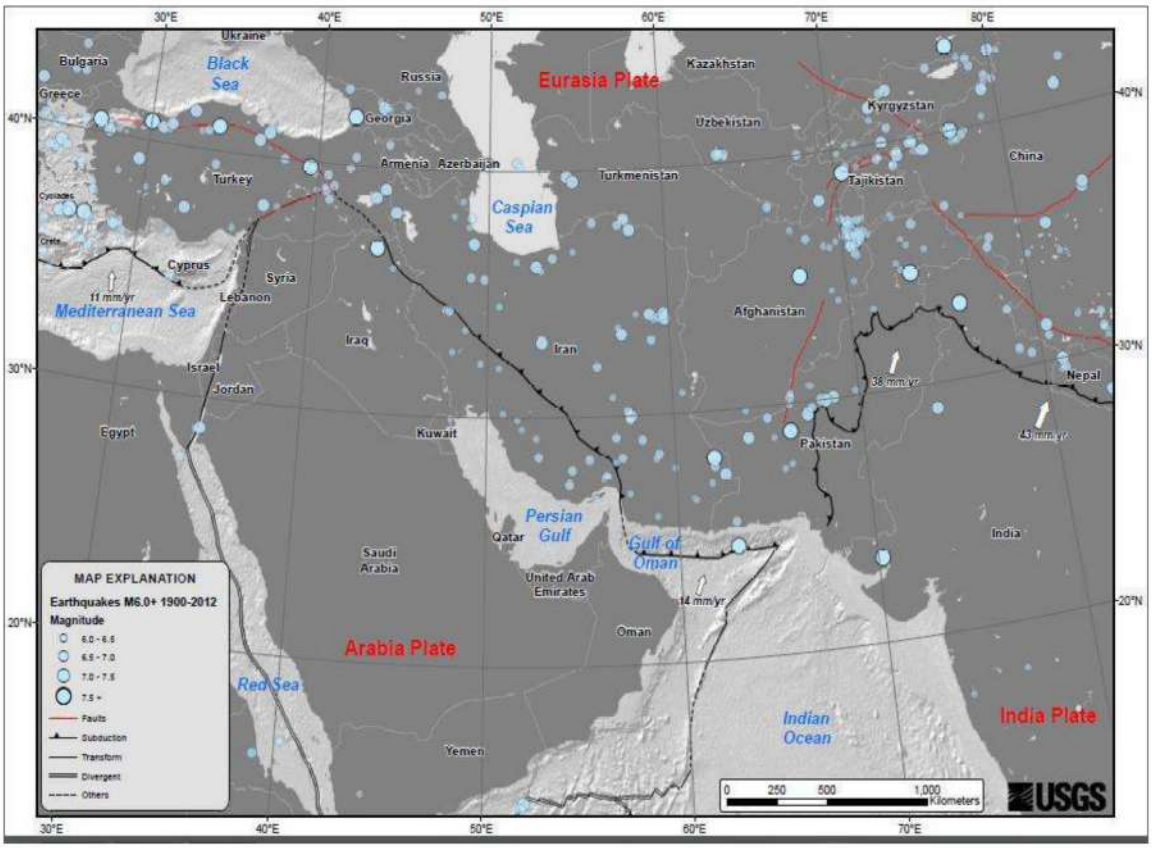

Figure 3: Plate tectonics of the region (Source: www.usgs.gov)

On a broad scale, the tectonics of southern and central Pakistan reflect a complex plate boundary where the India plate slides northward relative to the Eurasia plate in the east, and the Arabia plate subducts northward beneath the Eurasia plate in the Makran as shown in Figure 3. These motions typically result in north-south to northeast-southwest strike-slip motion at the latitude of the September 24 earthquake that is primarily accommodated on the Chaman Fault, with the earthquake potentially occurring on one of the southern-most strands of this fault system. Further, more in-depth studies will be required to identify the precise fault associated with this event. According to the USGS, although seismically active, this portion of the Eurasia plate boundary region has not experienced large damaging earthquakes in the recent history. In the past 40 years, only one significant event (M6.1), which killed 6, has occurred within 200km of the September 2013 event, in July of 1990.

Awaran district is one of the most backward districts of Pakistan. Apart from the district capital Awaran city, which resembles a town, there are no urban areas. The means of communication are limited and the inter-city road joining Awaran to Khuzdar on one side and Turbat on the other is a katcha track that is washed away every rainy season and the locals have to make a new track. The connectivity of Awaran city with Bela is slightly better as there is an asphalt road constructed with the help of USAID as shown in Figure 4.

Figure 4 The route from Bela to Awaran

Figure 5: Most of the land area in Awaran district is a water route like this

Because of the water route as shown in Figure 5, most of the human settlements in Awaran district lie along the Khuzdar-Awaran-Turbat track, which happens to run along a fault in the Euroasian plate. As a result of the recent earthquake, a crack developed in the ground that was spotted running almost parallel to this route in areas approximately 70 Km apart as shown in Figure 6.

The main settlements of Awaran district starting from North and going towards South are: Jabry, Nok Jo, the twin towns of Kullar and Gajjar, Mangoli, Awaran city, Malaar, and Gishkore. In all likelyhood, this region must have suffered from earthquakes but because of lack of records, it is not documented. The last major earthquake recorded in the vicinity of this region was the 1935 earthquake of Quetta, which had razed the entire city to the ground. Just 10 years later in 1945, a Tsunami hit Pasni, a town in Gwadar district to the south of Awaran. The Tsunami was probably generated by an under-water earthquake somewhere along the Euroasian and Arabian plates boundary.

Figure 4: The crack developed in the ground due to the recent earthquake

In spite of the region being close to the Indian and Euroasian plates boundary with the Arabian plate boundary nearby, and seismologists and geologists repeatedly claiming the presence of major active faults running through this region, little scientific measuring has been carried out to date. This is despite the fact that the national headquarters of the Geological Survey of Pakistan are located in the provincial capital Quetta.

SURVEY BY BUITEMS VOLUNTEERS

On 26th September, 2013, the Heritage Foundation contacted the Balochistan University of Information Technology, Engineering, and Management Sciences (BUITEMS), Quetta, seeking help in carrying out the survey of the earthquake affected areas and then dissemination of knowledge about and implementation of the vernacular methodologies for safe and economic construction so that the damage may be averted in case of a future similar disaster.

For this purpose, a team of the BUITEMS volunteers consisting of 2 faculty members, 4 students, and some local volunteers conducted the survey of the Earthquake affected areas of Awaran District from October 08 to October 14, 2013. The areas surveyed included: Jabry, Nok Jo, Color, Gajjar, Mangoli, Malar, and Gishkor of the Awaran District, and Dandar of the Kech District.

As the survey team visited the affected areas, not only the scale and magnitude of damage was realized, but also the causes of damage could be identified. The survey by BUITEMS volunteers was primarily focused on the assessment of the locally available construction materials and construction techniques in order to identify any shortcomings, which may be rectified in order to minimize the damage in case a similar disaster strikes again. The survey team started their journey

from Quetta by road on RCD highway. After a full day"s journey, the survey team reached Bela. They had their stay that the Lasbela University of Water, Agriculture, and Marine Sciences (LUWAMS) at Uthal. The newly appointed vice chancellor of the university, Dr. Dost Muhammad Baloch was very kind to provide excellent hospitality to the BUITEMS survey team. After spending a night at Uthal, the team started their journey towards Awaran and further on towards Mashkay. The road from Bela to Awaran, although being a single track, is made of Asphalt concrete as shown in Figure 4 above. The travelling on this road was not very difficult apart from a few sharp curves in the mountain pass.

On Thursday, October 10, 2013 at lunch time, the team arrived at Waja-Bagh as shown in Figure 7, which is a small town mid-way between Awaran and Bela. After having lunch and refreshments there, The team did not stay at Awaran. Instead, they took the bypass and Figure 4: The crack developed in the ground due to the recent earthquake continued their journey towards Mashkay the same day.

Figure 7: Waja-Bagh (a small town midway between Awaran and Bela

As the team moved further on towards Mashkay, it was realized that the land area of Awaran district is made of series of mountains with a wide valley in-between that serves as a passage for water when it rains in the north. This is also evident from the satellite image shown above in Figure 2. On the way towards Mashkay, the team spotted several water streams and ponds verifying the above statement. There was also found a lot of vegetation, some of which serves as construction material. The most notable plant from this point of view was the plant as shown in Figure 8, the leaves of which are used for thatching purpose in adobe house, roofing in houses made from mud-stacks, mud-bricks and sometimes even stone. The leaves of this plant are also used to make mats and other handicraft items, the making and selling of which forms an integral part of the local economy.

Figure 8: Pharha plant is found in abundance

Just when the sun was setting as it had already disappeared beyond the mountains but there was still a little twilight left, the team arrived at Mangoli. It was only then that the reality of the scale of destruction dawned on the survey team. The village of Mangoli was completely razed to the ground except for a few adobe huts. The villagers were going about their chores in preparation of evening meal. They were using some of the tents provided by the earthquake relief along with their adobe huts that were standing, some of which were even missing their side walls. Although it was getting dark and the initial intention of the survey team was to straightaway go to Mashkay and start the survey from there, the scale of destruction and the plight of the people of Mangoli didn't allow them to go onwards. They, therefore, made a stop there at Mangoli as shown in Figure 9 and started their survey right away. The survey methodology adopted for this field survey is described later in this report. After doing the survey at Mangoli, although it was already getting dark, the team continued their journey towards Mashkay.

Figure 9: The scale of destruction was beyond the initial notion

The team arrived at the town of Kullar in Mashkay tehsil late in the night and was warmly welcomed by the locals who offered excellent hospitality despite the fact that they were affected by the earthquake. The house where the BUITEMS team was staying had not fallen down during the earthquake but had developed cracks and the occupants were afraid to sleep inside the rooms. They had taken all their possessions out and kept them in the adobe huts. They were themselves living either in the tents provided by the earthquake relief or in huts.

The next morning, on October 11, the BUITEMS volunteers split into two groups. One group did the survey in the twin towns of Kullar and Gajjar whereas the other group of the BUITEMS volunteers moved further north towards the villages of Nok Jo and Jabry.

The twin towns of Kullar and Gajjar lie on either bank of the ravine, locally known as „kaur". A wide crack in the bed of this ravine could be found that was running along the length of the ravine. The town of Kullar is on the South-Eastern bank of this ravine whereas Gajjar is on the North-Western bank. There is a marked difference in the devastation caused by the earthquake in Kullar and Gajjar. While the town of Gajjar has been completed destroyed as shown in Figure 10, Kullar has only been partially damaged as shown in Figure 11. This trend can be found throughout the district. The places that are on the North-Western side of the ravine (presumably there is a fault underneath) have been more damaged compared to those on the South-Eastern side, which include the district capital city of Awaran.

Figure 50: Gajjar was badly damaged

Figure 61: Some structures were standing in Kullar

The other group of the BUITEMS survey team proceeded further north towards Nok Jo, and Jabry. It was the plan to go up towards north as far as the earthquake damages are visible. When the survey group reached Jabry, it realized that this is the last point where the earthquake had affected because there was very little damage to Jabry because of the earthquake. The story in Nok Jo was, however, totally different as shown in Figure 12. The entire settlement was razed to the ground and not a single structure could be seen standing except a few straw huts.

Figure 72: It was total destruction in Nok Jo

The survey team observed the presence of large orchards of Date-Palm trees in the Mashkay area as shown in Figure 13, which apart from being a very important export of the locality supporting the local economy, provides the bulk of the material for roofing.

Figure 83: Date-Palm orchards in Mashkay

The next day on October 12, the team completed their survey of Kullar and Gajjar and then started their journey southwards in order to do the survey of Awaran Tehsil. It took the team almost the entire day to reach Awaran. The team arrived Awaran just in time for the evening tea at about 5 p.m. After staying a night at Awaran and enjoying the hospitality of local people, the team continued their journey further south the next morning on October 13.

The first large village that the team visited on the southern leg of their journey was Malaar. This village was also completely destroyed and not many houses except a few straw huts could be seen standing. At the time the BUITEMS survey team arrived, relief goods were being distributed among the affected. There was a difference in the construction materials being used here in Awaran Tehsil from those in Mashkay Tehsil in that here, there was more use of stone boulders than mud bricks. The houses made from stone boulders had not fared any better as shown in Figure 14.

Figure 14: The use of stone boulders in wall construction was not much help

The BUITEMS survey team continued the survey further south covering the villages of Gishkore and Dandaar, which is in Kech district. By the time the survey was completed, it was late in the afternoon and the team decided to continue their journey onwards. When the night fell, the team had arrived at Hoshab, which is a town in Kech district. From there onwards, there could be found remains of the motorway, which was never completed. The BUITEMS survey team arrived at Turbat late at night and left for Quetta the next morning on October 14, 2013, just a day before Eid-al-Azha.

The BUITEMS survey team, fulfilling the primary purpose of the survey, collected information about the prevailing construction techniques and material used throughout starting from Jabry in the north to Dandaar in the south. The relevant information gathered is presented in the following section.

PREVAILING CONSTRUCTION MATERIALS AND TECHNIQUES

As stated earlier, the Awaran district is a valley running from North-East to South-West and consisting of a very wide water path with mountains running along both sides. Opposed to the general understanding that it is a barren area with scant vegetation, the valley is fertile with its own range of fauna and flora as shown in Figure 15. The northern part of the district, which consists of Mashkay tehsil and the settlements of Jabry, Nok Jo, Kullar, Gajjar, and Mangoli etc, is comparatively more fertile and has large plantations of Date Palms as shown in Figure 16. There are also other types of plants that grow in the region, the most important of which, from the point of view of contribution to the construction materials, after the Date Palm, is the Pharha plant. This area also has large deposits of alluvial soil brought along by the rainwater from the north, resulting in the abundance of mud available to be used as a construction material. In the Awaran tehsil towards south, however, the Date Palms reduce in population and there are more bushes and smaller plants as shown in Figure 17. The availability of mud for making bricks is also reduced and the use of round stone boulders can be seen increasing as we move further south. Going further southwards to the Ketch district, the taller trees can be seen again on the horizon. The geography and availability of materials is the chief determinant of the construction techniques. Following is an overview of the prevailing construction techniques prior to the recent earthquake.

Figure 15: Thick vegetation in Mashkay Tehsil

Figure 16: Date-Palms that are used for roof construction

Figure 17: Less vegetation can be found further south

Planning

There is not a lot of variation regarding the planning of houses as we move from Mashkay tehsil up north to the Awaran tehsil in the south. Most of the houses consist of 2-3 rooms located on the edge of the plot. There is no culture of boundary walls. The kitchen and the toilet are usually constructed separate from the main unit, the kitchen being right in front whereas the toilet being located on one side while taking care that it is away from sight of somebody approaching the house. The bathrooms are normally attached to one of the bed rooms. Some affluent families have bathrooms attached to every room. A plan sketched by the BUITEMS field survey team is shown in Figure 18.

Wall Construction

Wall construction techniques change from the mud-stack walls in the north in the towns of Jabry and Gajjar etc, to stone boulders in the south in the town of Gishkore, for example. The use of mud-bricks, however, can be seen almost throughout the entire district. The wall thickness is also constant throughout the entire district with 18" (450 mm) thick walls constructed everywhere.

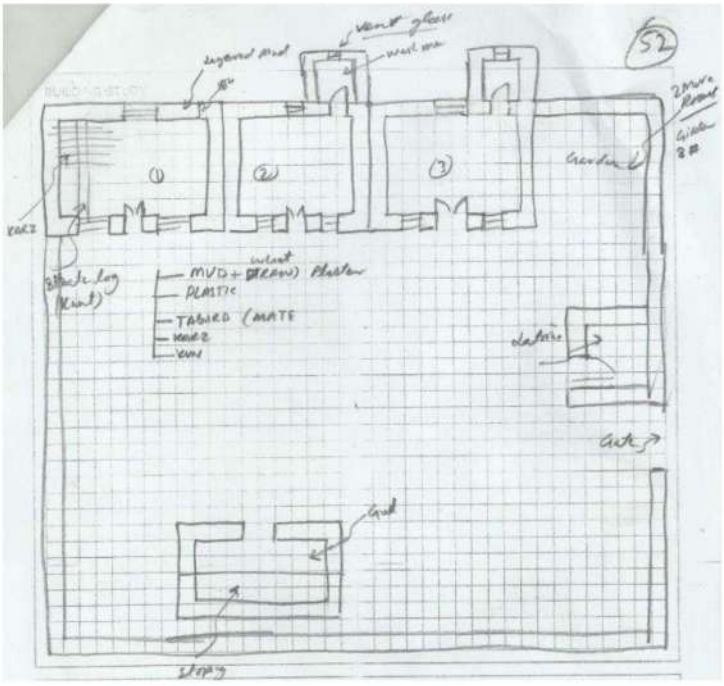

Figure 18: A sample plan of a house in Mashkay

Mud-Stack Walls

In the northern areas of the district, most of the walls are constructed with mud-stacks as shown in Figure 19. For this purpose, wheat husk and animal dung is mixed with mud in order to give it more strength. The foundations are normally laid 1-2 ft underground (300-600 mm) with the same mud-stacks but slightly wider than the wall. No stiffeners are used anywhere in the wall in horizontal as well as vertical directions. Wooden lintels are sometimes provided on the top of windows and doors in isolation, which have little affect towards strengthening the wall.

Figure 19: Mud-stack walls

Mud-Brick Walls

Mud-brick walls, as shown in Figure 20, can be found everywhere in the entire district. The bricks used for this purpose are made from a mixture consisting mainly of mud but that also includes small stones as well as organic material like weeds and reeds etc. The dimensions of the bricks being 4"x6"x12" (100x150x300 mm) are also constant throughout the length and breadth of the district. The bricks are generally made on plain ground using a mould made of steel plates which is open from both the top as well as bottom. This results in bricks with flat bottom because of the plain ground and flat sides because of the mould but the brick top is not properly flattened. The finished product, therefore, has a round belly protruding outwards on the top, which results in excessive use of mortar if it is tried to maintain horizontal courses. As a result, no proper bond was seen in use throughout the district. The bricks are laid horizontal, vertical, inclined, and every which way. The foundations for these walls are also laid about 1-2 ft (300-600 mm) underground which are mainly constructed with the same bricks as used for the wall. At some locations, the foundations made from stone boulders were also seen. Similar to the mud-stack walls, there are no stiffeners of any kind used in the construction of mud-brick walls. Also, similar wooden lintels were seen being used atop windows and door, which do not add to the wall strength.

Figure 90: Mud-brick walls

Stone Boulder Walls

As we move southwards towards Gishkore, the use of stone boulders for wall construction can be spotted as shown in Figure 21. The use of stone as a material for wall construction was more prevalent further southwards in the union council of Dandaar of Ketch district. These were mainly round stone boulders without any proper shaping or bonding and with the excessive use of mud-mortar. These walls also have the same width and are constructed without any stiffeners in any direction.

Figure 101: Stone boulder walls

Roof Construction

The roof construction techniques do not vary a lot as we move from north to the south. There are mainly two types of roofs constructed. The more affluent families construct the so-called Tier-Gaarder (T-Iron and Girder) whereas the majority construct the roof mainly from the Date-Palm branches laid over heavy wooden joists.

T-Iron and Girder Roofs (Tiled Roofs)

These roofs, as shown in Figure 22, are also known as 'tiled roofs' because of the use of ceramic tiles. This type of roof is constructed with steel girders of I-shape placed directly on the walls without any use of ring-beam. T-shaped steel sections, commonly known as T-irons and most of the times pronounced as 'tiers' are placed in such a manner that the flanges are at the bottom whereas the web protrudes upwards. This setting provides a seat for the ceramic roof tiles to be placed aligned between the two successive T-irons. The steel girders are ----, the T-irons are ----. The size of the roof tiles used is 1'x1' (300x300 mm) with a thickness of 1.5" (40 mm). A plastic sheet is laid on top of the roof tiles for insulation against rainwater and finally a screeding of mud-mortar of about 2" (50 mm) thickness is provided as insulation against heat.

Figure 112: T-Iron and girder roofs with ceramic tiles

Date Palm Roofs

Although the more prevalent name for this type of roof is 'katcha roof', it is named Date-Palm roof here because Date-Palms provide most of the material used for this kind of roof as shown in Figure 23. The roof consists of joists made from Date-Palm trunks after being split lengthwise. According to the local legend, the Date-Palms are termite proof if cut during the winter season. Sometimes, other materials are also used as girders for example, steel girders. The use of telephone poles as girders was also seen in some of the houses. All types of girders in these roofs are placed directly on top of the wall without any use of ring-beam or lintel band. On top of these girders, normally a net made of Date-Palm branches is used. In some cases the use of bamboo purlins was also seen. On top of the Date-Palm branches, a mat is placed followed by a plastic sheet for the purpose of insulation against rain water. Finally on top of all, a mud layer is provided as insulation against heat and cold.

Figure 123: Roof made of Date-Palm joists and Date-Palm branches serving as purlins

DAMAGE DATA

Because of the difficult terrain and lack of roads, it takes a long time in Awaran district to move from one village to another. Additionally, the fact that the BUITEMS survey team had limited resources at its disposal; it was not possible to carry out the comprehensive structural survey of each and every home destroyed in the earthquake. The majority of the houses in a particular locality were identical in construction and almost all of them shared the factors that had caused so much damage. In the light of the above situation, the BUITEMS survey team under the guidance from the Heritage Foundation decided to carry out the detailed structural survey of two representative houses from each locality that they covered. The significant data collected from those houses that were surveyed is presented below in Table 1:

Table 1: Field data collected about the damage caused to structures

S. No.	Name of Owner	Location	No. of Rooms	Wall Type	Roof Type	Extent of Damage
1	Nawaz	Dandaar	1 Room with attached bath	Stone Boulder	T-iron Girder Tiled	Completely destroyed
2	Rasheed	Dandaar	1 Room	Mud-brick	Thatched Roof	Completely destroyed
3	Yaqoob	Mangoli	2 Rooms with 1 attached bath	Mud-brick	Date-Palm Thatched	Completely destroyed
4	Raheem Baksh	Mehwer	1 Room	Mud-brick	Thatched Roof with Timber Log joists	Completely Destroyed
5	Abdul Wahid	Kullar	1 Room	Mud-brick	Date-Palm	Completely destroyed

6	Meer M. Akbar	Mehwar	3 Rooms with 1 attached bath	Mud-brick	T-iron Girder Tiled	Completely destroyed
7	M. Tahir	Mehwar	1 Room	Mud-brick	Date-Palm Thatched	Completely destroyed
8	Sher M.	Kuch	1 Room with attached bath	Mud-brick	Timber logs Thatched	Completely destroyed
9	Kareem Baksh	Kuch	2 Rooms with attached baths	Mud-brick	Timber Logs Thatched	Completely destroyed
10	Hatim Baloch	Kuch	2 Rooms with attached baths	Mud-brick	Date-Palm Thatched	Completely destoryed
11	Yar Muhammad	Kuch	3 Rooms with 1 attached dress-bath	Burnt Brick	T-Iron Girder Tiled	50% damaged
12	Basheer Ahmed	Kuch	1 Room	Mud-brick	Date-Palm Thatched	Completely destroyed
13	Muhammad Ali	Mehwar	1 Room	Mud-brick	Date-Palm Thatched	50%
14	Mosque	Mehwar	1 Room with Verandah	Mud-brick	Date-Palm Thatched	50%
15	Abdul Wahid	Kullar	1 Room with	Mud-stack	Date-Palm Thatched	Completely destroyed
16	Nasir	Mangoli	1 Room Shop	Mud-brick	Date-Palm Thatched	Completely destroyed
17	Abdul Haq	Mangoli	1 Room	Mud-brick	Date-Palm Thatched	Completely destroyed
18	Abdul Haq	Mangoli	1 Room with attached bat	Mud-brick	T-Iron Girder Tiled	Completely destroyed
19	Rashid Ali	Bozdar	1 Room with attached bath	Mud-brick	Timber Logs Thatched	50%
20	Muhammad Ameen	Bozdar	3 Rooms with attached baths	Mud-brick	Timber Logs Thatched	Completely destroyed
21	Ellahi Baksh	Sari Malar	1 Room with attached bath	Mud-brick	Timber Logs Thatched	Completely destroyed
22	M. Aslam	Sari Malar	1 Room with attached bath	Mud-brick	Timber Logs Thatched	Completely destroyed
23	Imdad Asim	Gishkore	1 Room with attached bath	Mud-brick	Timber Logs Thatched	Completely destroyed
24	Golab	Gishkore	1 Room with attached bath	Mud-brick	Timber Logs with Bamboo purlins	Completely destroyed
25	Jamal Khan	Nok Jo	4 Rooms	Mud-Stack	Date-Palms Thatched	Completely destroyed
26	Lal Jan	Nok Jo	3 Rooms with 2 attached baths	Mud-Stack	Date-Palms Thatched	Completely destroyed

Causes of Damage

The BUITEMS Volunteers survey team identified some factors that were responsible for the damage of such a large scale.

1. Improper Brick Making

The mud bricks that were being used in the area for the construction of walls were not even in the proper shape, save the proper ingredients. The bricks had roundish surfaces as shown in Figure 24, making it necessary to use excessive mortar at the cost of proper bonding between courses. Additionally, the material mix being used for the brick making was not up to the standard as it contained boulders as well as organic materials like reed stalks etc as shown in Figure 25.

Figure 24: Bricks laid out for drying

Figure 25: Some bricks in the debris

2. Lack of Bond

The brick courses were laid without following any proper bond pattern as shown in Figure 26. Some bricks were placed slanted while some were placed vertically. Whatever the reasons for using bricks in that manner, they made the walls vulnerable to even a slight jolt.

Figure 26: A portion of a wall in Mangoli showing lack of bond

3. Use of Heavy Girders

In most of the houses, it was seen that heavy girders were being used without any proper mechanism of load distribution as shown in Figure 27, for example. As a result, the concentrated load from the heavy girder was applied to only a few bricks which failed easily. The girders being heavy caused a lot of structural damage and may also have been single handedly responsible for any loss of life that occurred.

Figure 27: Heavy girders caused damage

4. Lack of Projections

The roofs were placed on the walls, as shown in Figure 28, such that there were no projects on any side. As a result, when the walls moved even slightly, the roof came down pushing the walls further while doing so. As a result the entire houses collapsed.

Figure 28: Lack of projections

5. Weak Corners

It was observed that in most of the construction, the corners were not strengthened and as a result they gave in easily when the walls started shaking, as shown in Figure 29, for example. The classic case of weak corners is evident in Figure 5 where a structure had all its four corners damaged. Following pictures show more such evidence.

Figure 29: A case of a weak corner

6. Pre-earthquake Damage

Most of the mud and mud brick walls were already weakened by the rainwater mainly due to spouts not having the required projection, as shown in Figure 30, for example. This had made the walls weak and thus vulnerable.

Figure 130: Damage caused by water spouts

CONCLUSION

Although the earthquake that occurred in late September, 2013 was of the magnitude 7.7, which is expected to cause a lot of damage to structures, it is the conclusion drawn from the field survey by the Authors that in this particular case, excessive damage might have been avoided had there been engineered construction prevailing in the area. Also, from the point of view of developing infrastructure, it is felt that the provision of better road network connectivity may help not only in the quick response to such a disaster but also dissemination of knowledge through social contact.

ACKNOWLEDGEMENTS

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How Photovoltaics are more advantageous than other power generation technologies?

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Abstract

This research is based on the working of photovoltaic in the electricity generation. It also gives an idea that how photovoltaic can be more productive than the hydro power plant and wind turbines with lesser disadvantages. There are many areas in photovoltaic technology which are being researched in different parts of world. The researches mostly, are done to reduce the cost of the making of solar cells and panels. The different applications clearly tell how other methods of electricity generation are consuming the high cost and the natural resources, contributing to global warming.

This extensive research will conclude into the feasibility and the effectiveness of solar panels in electricity generation and also, the applications of solar technologies from the daily life, the current usage of the solar energy technology and the prospective future it can have, in the time to come as well as the production of cheaper PV modules used for either commercial or domestic purposes.

Introduction

Solar energy is the energy gained from sun in form of light and heat. Sun is the never ending source of energy, as far as the earth exists, sun will revolve around it. So, technically this source of energy is infinite and very useful if used for beneficial purpose. In ancient times, solar energy was used for drying, warming homes, placing fire through magnifying glass and for other purposes. Now the technologies evolved and the proper solar energy technologies are being used. [1]

Solar energy technologies are classified into two groups.

- Active Solar
- Passive Solar

Active solar

Active solar technologies merely change energy from one form to another. The heat energy is changed into electrical energy and is used in commercial or domestic use for different purposes. Electrical or mechanical equipments are used for conversion of active solar energy. In the active systems, controls can be used for maximized effectiveness. A small amount of energy is maximized to the larger amount of thermal energy. It also gives the variety of choices for utilization and usage. [2]

Passive solar

Passive solar technology is used widely in building architecture. An ideal design balances the energy requirement without the additional mechanical equipments. The heating and cooling through passive solar energy minimizes the usage of electricity, thus, saving energy as well as reducing the cost. The landscaping, walls, floors, windows, roof and the exterior of the building is designed in such a way that it controls the amount of heat entering and leaving the building. The solar radiation is minimized by the shades and generation of air flow through

conventional ventilation. This is called cooling by passive solar technology.

The use of electricity in the commercial buildings can be reduced by the usage of the day light as well as the surrounding skylight. The heat is reduced by the absence of heat produced from lights and bulbs. The strategic planning before design can give the maximum usage of solar energy.

In passive cooling, buildings are designed in such a way that they keep solar and air heat away. Internal heat either from movement or from the non-movable objects is distributed or circulated through ventilation. Shading devices are very helpful for the building exterior; they can reduce the entrance of heat inside up to 90% while still allowing the indirect light inside the building.
Passive solar heating is totally opposite to the solar cooling, as it allows the heat absorption through different objects to keep the structure warm throughout. The orientation of the windows are kept in a way that it helps gain the heat and once it is inside, it spreads using different techniques. The loss of heat can be avoided by keeping the structure air-tight. [3]

Photovoltaics

Photovoltaic is a technique of electrical power generation, by the conversion of solar energy into direct current electricity. Solar panels composed of small solar cells are used in the photovoltaic power generation. Semiconductors, presently use that show photovoltaic effect include mono crystalline silicon, polycrystalline
silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide.
Photovoltaic systems are made up of solar panels, AC/DC convertor, racks to hold solar panels, electrical interconnections and rack for other equipments like backup battery, charger, energy management software, maximum power point tracker (MPPT), solar concentrators etc. The electricity generated through these photovoltaic systems can either be used directly or stored or sent to the grid-tied plants or used in hybrid-plants. These systems are designed in such a way that they produce the highest possible outcome from the minimum possible investment. [1], [4]

Solar cells

The solar cells convert the solar energy into the flow of electrons. Photovoltaics use the solar cells and create the photovoltaic effect. The electrons are excited to the higher state of energy by the photons, acting as charge carriers for an electric current. The current flows typically due to the transduced light energy thus all the photovoltaic devices are photodiodes of some type.
The direct current electricity is produced by the solar cells which can be used in power plants or for other uses. Cells are connected together to form solar panels or modules, depending on how much energy is needed. For power plants or bigger stations, a single cell must be arranged in arrays. Cells must be protected by the outer environment; this is why they are usually packed inside the glass.

"The power capacity of photovoltaic is measured as maximum power output in "Wp" (Watts peak) under standardized test conditions (STC)". The actual power output may be different from the standardized one, lesser or greater, depending on the different conditions, like time of day, location, weather changes etc. To maximize the output, the terrestrial photovoltaics are aimed to face the sun with the movement. Generally, solar trackers move the photovoltaic panels. The analysis of path of the sun can optimize the mounted systems. The angle of the panels could be set according to the latitude and climate. The performance of photovoltaics is reduced on the temperature above the standard room temperature, just as the case with other semiconductors. The demand for photovoltaics is increasing rapidly; many of the countries are utilizing solar technology for power generation. "World solar PV capacity (grid-connected) was 7.6 GW in 2007, 16 GW in 2008, 23 GW in 2009, and 40 GW in 2010". [5], [6]

The photovoltaics are installed on roof tops or ground depending on the consumer. The photovoltaics are the third most renewable energy source, installed globally. The capacity factor of the photovoltaics is only 25%, which is lower than the most of the industrial use. Apart from that, the sun hours from different countries and locations are 2.5 to 7.5 hours per day. The output power is rated on the panels under the standard conditions. The combination of shading, tracking and tilt can affect the yield. Tracking increases the yield but the cost is also increased. The installation and the maintenance require the constant cost throughout. "A dual axis tracker can increase the effective insulation by roughly 35–40%, while temperature effects can reduce efficiency by 10%. The AC output is roughly 25% lower due to various losses including the efficiency of the inverter" [7], [8]
The efficiency of solar cell may vary, ranging from 6% for amorphous silicon to 44% for multiple-junction photovoltaics. [9]

The solar cells are also manufactured by the deposition of photovoltaic material on flexible substrate like ordinary paper by using chemical vapor deposition technology. The five

layers of organic photovoltaic circuits are coated on ordinary paper substrate, inside the vacuum chamber. This research is known as the flexible solar cell research. It was developed by the researchers in MIT (Massachusetts Institute of Technology) in collaboration with NSF (National Science Foundation) and the Eni-MIT Alliance Solar Frontiers Program. [10]

Concentrated photovoltaics

Concentrated photovoltaics (CPV) are made with a magnifying glass over small solar panels, thus, concentrating the sunlight. The overheating may occur if there is no efficient heat-sink design for cooling as the high temperature reduces the life and efficiency of photovoltaic cells. The heat-sink design must be passive as the active cooling will consume some power, reducing the efficiency. [11]

Comparison of photovoltaics with other renewable energy technologies

Hydroelectric power is the other source of energy gain from the flowing of water with electric generator connected with a turbine to provide power. It doesn't pollute the environment nor create the waste products. Water once used in the process of producing electricity can be reserved by the method known as "pump storage" and can be used again when there is a high electricity demand which enables the generator to start up quickly when reusing again and produce high output voltage. Apart from this the conventional hydroelectric power are expensive to build, destroying the habitat with it and also requires huge space to generate electricity.

Wind turbines convert the wind power to electricity. Usually wind turbines require such an area where there is wind and also occupies a large space of land or even in sea. Small wind turbines can be installed on the rooftops. Wind turbines same as other energy sources do not emit hazardous gases not it pollutes the environment. [12]

At some areas intermittency occurs where there are several intervals of wind that area. Being faced by intermittency doesn't really affect the energy being produced in the grid. It is usually a very small change which can be negligible. Apart from this, wind penetrates energy according to the energy stored in the grid. For a 100% penetration it requires a very long storage which might take a week, month or a year. Based on the other facts, wind turbine is cheaper to build as compared to hydro powers but hard to maintain. Capacity factor is an indicator of how much energy can be produced by a wind turbine in a particular place. Comparing all the three energy sources, the Photovoltaic capacity factor in Massachusetts ranges from 12-15%, the hydro power ranges from 30-80% whereas the wind turbine ranges from 20-40% only. [13]

Sun, being an endless source of energy for the PV system, solar panels are abundantly used in many applications; on rooftops, electronic devices, streetlights, gardens etc. The structure makes a PV system environmental friendly; having no moving parts so do not cause any intoxicating gas in the atmosphere. One of the best advantages of PV systems is the "grid connection" method in which consumer can generate own power after installing the solar array. The DC power is converted to AC power and is then distributed to the utility grid/electrical grid or makes its path directly to the AC loads when the grid is not energized. There could be a further connection with the grid, from which the consumer can sell the excessive electricity generated through PV system. [14]

On the other hand, PV systems are too expensive to purchase and are heavy in weight. The efficiency of solar panel is less than the efficiency of solar cells due to the structure of solar cells and the glass covering the panels, some sunlight may get reflected. The higher the efficiency of the solar panel the more the savings because the amount of electricity received is higher. Therefore it results in low cost utility bills. [15]

SOLAR CELL EFFICIENCY

The converted percentage of electrical energy from solar energy is known as the energy conversion efficiency (η) of a solar cell.

It is calculated by $\eta = \frac{P_m}{EA_c}$

Where,

P_m is the maximum power output,

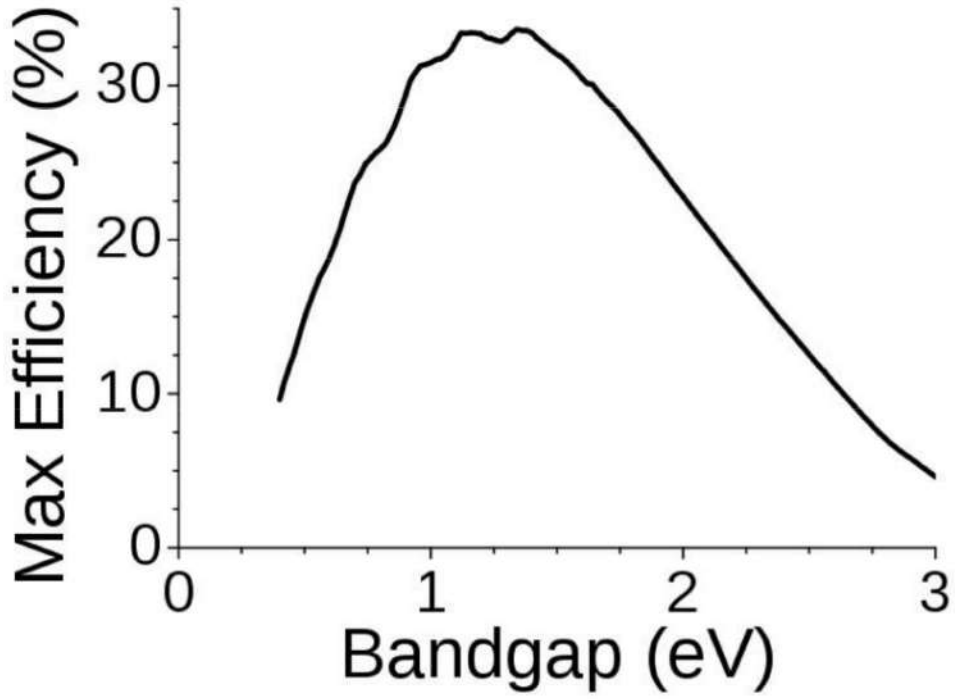
E is the input light falling on the solar cells and

A_c is the surface area of the solar cell measured in m^2.

There are multiple factors that affect the value of cell's conversion efficiency including the reflectance efficiency, conducting efficiency, charge carrier separation efficiency and thermodynamic efficiency values. All these parameters are difficult to be calculated or measured directly so the other parameters; quantum efficiency, V_{OC} ratio and fill factor are measured. Reflectance losses are reasoned by the quantum efficiency value affecting the "external quantum efficiency." Recombination losses are reasoned by the quantum efficiency, V_{OC} ratio, and fill factor values. Resistive losses are principally reasoned by the fill factor value, but also contribute to the

quantum efficiency and V_{OC} ratio values.

"The maximum conversion efficiency for sunlight is 86%, theoretically, due to Carnot limit, given the temperature of the photons emitted by the sun's surface." [16]



(The Shockley-Queisser limit for the efficiency of a single-junction solar cell in un-concentrated sunlight, this calculated curve uses actual solar spectrum data, and therefore the curve is wiggly from IR absorption bands in the atmosphere. This efficiency limit of ~34% can be exceeded by multi-junction solar cells.)

FACTORS AFFECTING ENERGY CONVERSION EFFICIENCY

- **THERMODYNAMIC EFFICIENCY limit:** The solar cells act as quantum energy conversion devices and subject to thermodynamics efficiency limit. Photons with an energy lower than the band gap of the absorber material cannot generate a hole-electron pair resulting in energy not converted to useful output and if absorbed generates only heat. The photons with an energy above the band gap energy, the useful output is generated by only a fraction of the energy which is absorbed, above the band gap. The absorption of photon with greater energy results in the excess energy above the band gap converted to kinetic energy of the carrier combination. The excess kinetic energy is then converted to heat through phonon bombardments and also, the kinetic energy of the carriers slows to equilibrium velocity.
- **Quantum efficiency:** It is referred to the percentage of converted photons into electric current in the short circuit conditions. The transmission and reflection are the losses with the external quantum efficiency of silicon solar cell. Internal quantum efficiency refers to the efficiency of absorbed photons that generate collectable carriers.
- **Maximum power output:** A solar cell operates in a variety of values of voltage and current. The maximum power output can be determined by increasing resistive load on an irradiated cell continuous from zero to a very high value i.e. from short circuit to an open circuit. The maximum power output is dependent upon incident illumination.
- **Fill factor:** *"This is the available power at the maximum power point (P_m) divided by the open circuit voltage (V_{OC}) and the short circuit current (I_{SC})." It defines the overall behavior of the solar cell.*

$$FF = \frac{P_m}{V_{OC} \times I_{SC}}$$

$$= \frac{\eta \times A_c \times E}{V_{OC} \times I_{SC}}$$

Fill factor is affected by the shunt resistances and the series of the cell. The cell has maximum output theoretically, resulting in greater efficiency, when the shunt resistance is increased and the series resistance is decreased. This leads to a higher fill factor. [16]

Energy payback

The recovery time for generating the energy spent on manufacturing a PV module is defined as the energy payback time. Depending on the module type and the location it is installed in, it is estimated to be 1 t0 4 years. According to their typical lifetimes ranging from 20 to 30 years, they can generate more energy over their lifetime than the energy spent in their production. This gives an idea of the estimates to be precise and reliable. Modern solar cells will be net energy producers.

Table of Comparison

The table below gives the main factors about each of the power generation methods being compared.

SOLAR POWER	WIND POWER	HYDROELECTRIC POWER
1. Sun light is free.	1. Wind is free.	1. Water is free.
2. Sunlight is abundantly present in hotter areas but there is day light every day and everywhere.	2. Wind is not abundant everywhere, some areas might not have any wind at all.	2. Rivers are found in some countries, thus making it difficult for everyone to consider hydroelectric power.
3. Solar power is environmental friendly.	3. Wind turbines make noise.	3. Dams are built where there is a huge space for the water to flow but they are quite far from residential areas.
4. Installation is much cheaper as compared to hydroelectric power.	4. Installation is much cheaper as compared to hydroelectric power.	5. It is very expensive to build a hydroelectric power dam.
5. Excessive Sunlight can be available at midday and when there is no cloud to produce large amount of electricity.	5. A large amount of wind is needed to generate electricity.	5. Pressure of the water is not always constant.
6. SEGS CSP being the largest Power plant produces 354MW of electricity.	6. Global wind capacity has produced 10,000MW of electricity.	6. Hydroelectric power plant has produced 3,427 tetra-watts in 2010.
7. Solar panels can be installed easily on rooftops or gardens/streets.	7. Wind turbines are also easily installed on rooftops considering the direction of the wind.	7. Keeping in mind the habitat of the animals, Dams are installed in a wide space destroying many homes forcing the creatures to relocate.
9. Solar panels do not affect any wildlife.	Wind turbines are a threat to the wild life i.e. birds etc.	Dams are a threat to marine life i.e. fishes, marine plants, etc.
10. The efficiency of solar panels depends up on the location and environment where they are kept. It can reach up to 11% - 19%	10. The efficiency depends on the factor of how much the speed of the wind is. It ranges from 40% - 60%	10. Efficiency depends on the type of turbine used and can reach up to 95% of efficiency.

[16], [17], [18], [19], [20], [21], [22]

Applications of photovoltaics

Photovoltaics are already being utilized and applied in many new inventions and technologies. Where, there were other methods used for any specific purpose are now replaced with the new solar technology. Some of the simplest PV applications are agriculture, Industry Telecommunication & Public Services, Residential, Health and pharmaceuticals, Leisure and entertainment and many more. Though there is more to it. [23]

The sunny days which contribute in drying out plants, heating up buildings and evaporating tons of sea water also contribute in generating electricity

with photovoltaics. The energy can be produced there and then when needed without complex wiring structures and control systems.

Small simple PV systems under 500 Watts are easily portable. Only few hours of installations are required and they demand occasional cleaning and maintenance.

PV systems with power backup or storage are much more reliable generating power when there is no external light or low sunlight. Many of the industries and domestics all around the world use PV systems with battery storage to generate power for lights, appliances, sensors and different electrical equipment which require power to be operated. The batteries of PV system can be designed either to power ac equipment or dc equipment. When the conventional ac equipment is operated with the PV systems, inverter between the batteries and load should be placed for power conditioning. Small amount of energy is lost in conversion of direct current into alternating current. For operation, PV modules are connected to a battery and the battery is connected to the load. The battery is charged in the daylight hours and the load gets power supply by battery whenever needed. A charge controller should be placed with the batteries which helps the battery to be charged properly and avoids the complete drainage or the overcharging.

Batteries add backup to the PV systems when there is no direct sunlight. They require regular maintenance though. They require the same care and pose the same risks as automotive batteries. A solar generating system with backup batteries can easily supply energy whenever it is needed though the amount of electricity stored and generated depends upon output of PV modules and the battery bank. A system should be well designed as the extra PV modules and batteries increase the cost of overall system. The energy requirement should be carefully calculated and studied.

PV modules with generator can be used for the higher demand of electricity when there is no sunlight or the difference is needed to be making up when the demand exceeds combined output of batteries and PV modules. Similarly, when the utility power is available, it can be used in place of batteries with the PV modules. This can lead to the lower electricity utility bills and can benefit the owner of the PV system, if the extra power generated is sold. Even the utilities are showing great interest in the photovoltaics. They are planning for hybrid power systems which meet energy demand for a particular area. [24]

New technologies and researches

New advancements on the electricity generation have been discovered recently and in the past few years. One of the inventions is the "Gratzel cells" which were being worked on since 1988. The Gratzel cells in this regard consist of two electrolytes with one end of fluoride-doped tin dioxide (S_nO_2F) at the anode and the other end with iodide as the cathode. A thin layer of titanium dioxide (TiO_2) nano particles is made a sandwich between the conductive plates which allows the sunlight to be absorbed in a very small fraction. Along with the most important ingredient is the photosensitive dye (ruthenium-poly pyridine) is soaked with TiO_2. At the end the plates are sealed together to prevent the leakage of the electrolyte. [25].

These cells are relatively cheap due to the elements used as compared to that of solar cells. The normal efficiency of solar cells recorded as low as 4-5% and the Gratzel cells can produce an efficiency of 11%.Another application of PV is the "Solar Steam" which of course produces steam and is used in every field and has its own advantages in medical field to sterile medical waste, in food, in the purification of water and almost 90% of electricity is produced by steam. By the help of nano particles, the sunlight is converted into heat and when mixed with water produces steam.

RTI (Research triangle Institute) has discovered new technology known as "Colloidal quantum dots" which is likely more affordable and can have the same power conversion efficiency such as that of normally used solar cells. Colloidal quantum dots have the electronics property with a tunable optical which is adjusted according to its quantum size effect. These are inorganic semiconductors which are composed of both organic and inorganic materials processed in a solution in which the organic materials are synthesized with the inorganic semiconductor. The materials used can be accessed on as low cost as 75% as that of the normally used solar cells. [26], [27].

Economics

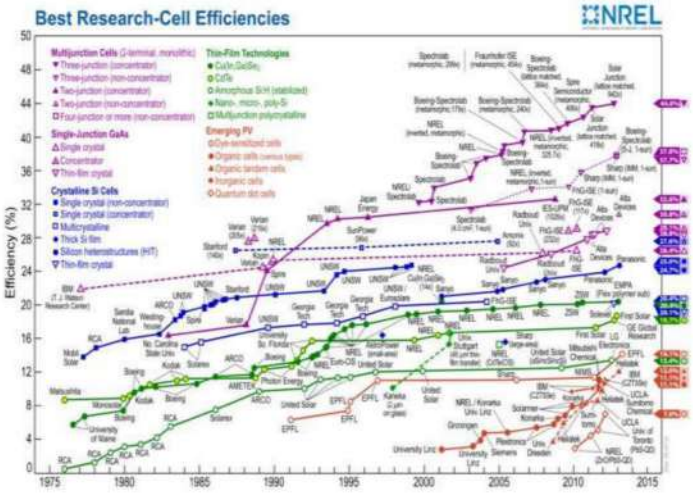
Lesser the solar power costs, more it is favorable for the consumers as it becomes attractive to the utilities and all of the power generating plants around the globe. It can deliver the cheaper power to different locations cheaper than the other peak generators and low cost natural gas. The demand for PV modules in consumer market is stimulated by the low costs of the solar modules as the cost of PV modules compares favorably by the utility electric rates. The further research in reducing the cost of PV modules is being conducted at MIT, and by the end of the decade manufacturers in US shall

be able to develop less than half as expensive solar panels as they make now. It would be cheap enough to compete with the electricity made from fossil fuels. The technology will be used for such cost reductions and may involve the silicon from which the solar panels are made today. [1]

The best way to reduce the cost of solar cells is to increase their efficiency means more power can be generated in the given amount of material. It also decreases the installation costs as fewer panels are needed. Though the improvement in efficiency is not enough, the solar cells shall be made with the thin wafers of silicon and the silicon is used to make wafers in such a way that wastes less silicon. The reduction of cost is not possible if highly efficient solar cells are manufactured in a slow pace or requires thick silicon wafers.

The alternative processes can be used to the process, used now which produces the useful silicon as waste. Some processes are the making of thin wafers from the pool of molten silicon, chemical etching and peeling them off. It is possible make usable thin silicon cells up to 25 micrometers but mostly manufacturers rely on up to 180 micrometer cell due to more durability.

The technology mentioned above is not yet demonstrated fully. The reduction of costs of PV modules also depends upon the costs of installers, inverters, wiring, land etc. Eventually the cost shall drop to be afforded by almost everyone generating power which the natural source and reducing global warming as well. [28]



(Timeline of solar cell energy conversion efficiencies (from National Renewable Energy Laboratory [USA])

Conclusion

Economically, solar panels can be expensive on such a low generation of output for a vast location but besides the economical factor, the global warming is the biggest threat world is facing. Power back up systems or the rechargeable batteries can be used to store the power.

Wind turbines and dams are harmful for wildlife. The global warming has started to consume the life on earth, resulting in loss of a lot of water from seas, changing the wind pressure differently and daily. The other resources like fuels are also about to be extinct. To meet the requirements of the growing population and to keep the earth still a better place for the generations to come, the solar technologies can be the biggest achievements especially in form of power generation techniques. The decline in the cost is inevitable once this industry emerges fully fledged. This requires the detailed planning to utilize the solar energy to the fullest. Once, it is done it will be cheaper and healthier for the environment.

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Harnessing Tidal Energy Resources

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History was made when performance of the world's first tidal underwater turbine of one megawatt capacity was successfully demonstrated recently in Orkney Isles, Scotland, which has established commercial viability of harnessing the tidal energy resources.

The machine HS1000, developed by Andritz Hydro Hammerfest, was installed at the European Marine Energy Centre's tidal test site in December 2011, and since then the turbine has underwent extensive testing during its continuous operation, with focus on comparing measured load and performances with figures calculated during the project design phase. Results were very positive and machine was found generating grid-compliant electricity of over 3 GWh annually, meeting its design parameters fully.

The turbine, developed on most advanced concept, has rotor diameter 21 m, depth of 50 m underwater, rotational speed 10.2 rpm, operating in a 4 m/s tidal current, and is capable of delivering power with 98% availability. The state-of-the-art machine is a horizontal axis turbine, similar to a wind turbine, mounted and locked onto a solid steel structure and positioned on seabed. The rotor blades are driven by water currents and coupled to an electric generator through a step-up gearbox. A dedicated blade pitching system allows optimum adjustment of the rotor blade to the direction and speed of the tidal current. Electrical power is transmitted onshore by means of a subsea cable connected to the grid.

Scottish Power Renewables has already selected these turbines for its 10-MW tidal turbine array in the Sound of Islay (Scotland), which would be the world's first tidal turbine array, and subsequently, for use in Duncan by Head (the Pent land Firth) project of 95 MW scheduled for completion by 2020. Scotland is the world leader in the commercial development of wave and tidal energy having commenced power generation in November 2000. Generating electricity using tidal currents in coastal waters is an enormous challenge. The related technology, though emerging, is well-proven as the first large-scale tidal powerhouse was established in France in 1966. Since then a number of tidal power stations have been constructed. These power stations have mostly installed bulb type turbines along generator, similar to that of hydroelectric power station.

Research and development continues in its design, installation and maintenance, with a view to mainstreaming these technologies so that it becomes cost effective. In recent years there have been major advancements taken place in wave and tidal energy technologies. The recent tidal power stations are based on the concept of windmill---tidal energy unit functioning like an

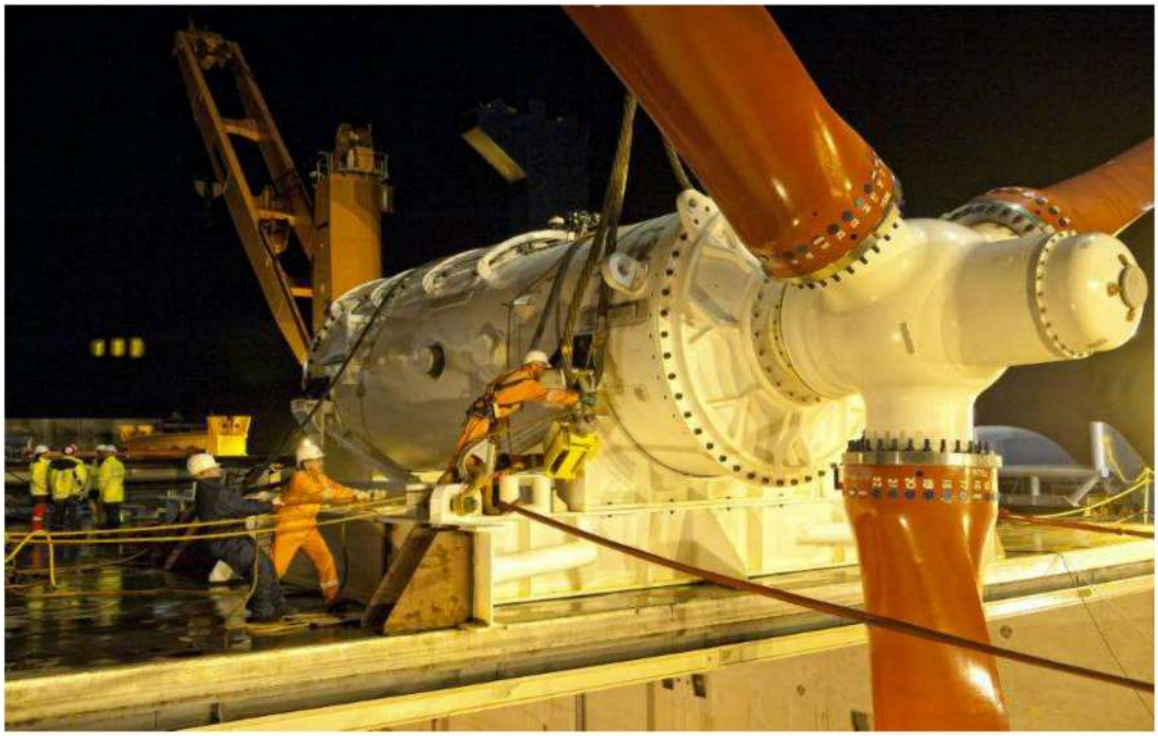
underwater windmill, without requiring construction of tidal barrages/dams. All leading companies in technologies for energy generation, namely Alstom Hydro, Andritz Hydro Hammerfest, Atlantis Resources Corporation, OpenHydro, Scotrenewables Tidal Power and Voith Hydro, have been actively engaged in developing tidal turbines for commercial-scale power generation.

turbine weighing 1,500 tons, which is currently undergoing tests at the European Marine Energy Centre.

Atlantis Resources Corporation's AK 1000 largest bladed tidal turbine and Voith Hydro's HyTide 1000, both of one megawatt capacity, are also currently under tests and trials in Orkney Isles. Scotrenewables Tidal Power has developed unique floating

India in the Gulf of Kutch.

Theoretical global ocean energy resources are estimated to be over 32,000 GW. Interestingly, net potential of both wave and tidal power is greater than wind and solar, in global perspective. Tidal energy, a form of hydropower, is clean, environmentally friendly and more predictable compared to wind energy. Tidal power has the greatest



Open Hydro and Alderney Renewable Energy will develop, in joint venture, a 300-MW tidal energy array off the coast of Alderney in the English Channel, using 2-MW tidal turbines. Swansea Bay Tidal Lagoon project in South Wales of 320 MW will be the largest tidal turbine in Europe to be completed by 2018. UK electricity supplier Good Energy has already agreed to purchase electricity from the proposed project that would install Alstom's most powerful single rotor AR 1000 tidal

tidal technology to minimize installation and operating costs. After successful modelling of 250 kW unit, the company is in the process of launching larger commercial scale 2-MW turbine, more suited to tidal array development. China has recently established 3.2-MW tidal power station, and has signed agreement with the Netherlands to develop world's largest tidal power project based on new tidal technology. Construction of 50-MW power plant has been undertaken by

energy density (watts/cum per second) compared to solar (medium) and wind (lowest).

Tidal power belongs to most efficient renewable energy resources, with about 80% efficiency. It has high initial capital cost, whereas cost for establishing infrastructure is the same as for wind-based power, but it is inexpensive to maintain. Other benefits include lower project construction time as tidal turbine can be installed in 9-10 months. However, power

generation cost, which is in the range of Cents 10-12 per kWh, is considered higher compared to other sources.

There are many other new resources of energy that could benefit Pakistan in the long term, such as ocean energy including marine current power, osmotic power (from salinity gradients), ocean thermal energy, oceanogenic power (from surface waves), wave energy and tidal power. Pakistan has not yet done any work in this direction despite having various strategic locations with high tidal current velocities or strong ocean currents along its 990-km coastline. Tidal energy resources offer an inexhaustible supply of energy. Pursuant to the government policy for the development of alternate energy resources through private sector the government has allowed in February 2013 setting up tidal energy projects of cumulative capacity of 10 MW at Sonmiani Bay (Balochistan), but so far there has been no physical progress achieved.

According to a study conducted by the National Institute of Oceanography, creeks network in the Indus deltaic region extending over 70 km along the Arabian Sea can alone generate 900 MW tidal power. Detailed study, testing and assessment of tidal energy across the coastline could show huge potential of marine energy resources that can be exploited for power generation on commercial scale. In future, tidal power could be a significant part of the renewable energy mix in Pakistan. Tidal power stations can be constructed grid-based or off-grid installations, depending on site conditions.

In view of the emerging energy scenario the world over, more focused approach by the government towards developing non-conventional and renewable energy resources is required. Optimal exploitation of tidal energy resources has potential to provide solution to the prevalent power crisis. A proper policy on tariff and commercial development of these resources, providing enabling environments to the investor, both domestic and foreign, will be helpful. There is therefore a need to give policy directive for encouraging promotion of these indigenous resources too, in line with the neighbouring countries like India and China where such resources are being rapidly harnessed economically.

(**Engr Hussain Ahmad Siddiqui** is Chairman of the Institution of Engineers, Pakistan -RIC)

Courtesy by DAWN

Wapda May generate more hydel power this winter

Lahore: The hydel power stations operated by Water and Power Development Authority (Wapda) have so far contributed more electricity to the national grid during November as compared to the corresponding period of last year. Likewise, the hydel power generation is set to increase during upcoming December and January as well. This increased generation is due to better hydrological conditions particularly in relation to Mangla reservoir, and effient operation and maintenance of hydel power stations. The enhanced production of hydel electricity comes at a time when the country is in acute need of electricity to run the engine of economy. The additional quantum of electricity will not only help minimise load shedding during the winter season but also lower power tariff thereby providing relief to the people. According to available data, contribution of additional hydel electricity to the national grid has ranged between 500MW and 650MW on an average for the current month so far as compared to corresponding period of last year. In the same way, the increased hydel power generation is likely to range between 400MW and 500MW in December 2014 and 300-660MW in January 2015 on an average. These projections are based on Irsa's Reservoir Operation Criteria for Rabi Season 2014-15.

Significance of Management Commitment Towards Safety In Construction Industry of Pakistan

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Abstract

Construction industry is prone to high risk. There is a need of proper management which could reduce this risk and improve safety of construction project. Management commitment significantly affects labor behavior. As labors are motivated towards safety but poor instructions by the management, let them to perform unsafe. This research study whether management committed towards safety or not and relate management commitment with labor behavior. For this, survey was carried out at different construction sites of Pakistan and data was collected using a questionnaire. Data analysis was performed by using statistical techniques. The results indicate that management claim that they are highly committed towards safety but when their statements are cross checked with labor, they found to be not true which ultimately result in unsafe labor behavior. Moreover management not have overall frame of reference for getting appropriate feedback from labors. If they take feedback of their performances, they can improve their commitment towards safety. Finding reveals that there is need of supportive physical, human & organization environment from management. Management should train labor, announce rewards for labors who worked safely etc. If management become strict and implement safety properly, then the unsafe conditions of construction industry and labors can be defeated.

Keywords: Construction Industry of Pakistan, Labor Behavior and Management Commitment.

Introduction

Construction industry is considered as the third highest risky industry in the whole world after mining industry and agriculture industry (Shaikh et al., 2013). However except of the highest risk, in the developed as well as developing part of the world, construction industry is considered to be one of the most significant industries in terms of contributing to GDP and also in terms of its impact on health and safety of the working population (Farooqui et al., 2008). But in the construction industry of developing countries, occupational safety remains neglected because of competing social, economic, and political challenges (Irfan, 2013). Construction in Pakistan is more labor intensive (Farooqui and Arif, 2009), but studies have shown that project superintendents play a significant role in determining the safety performances on their projects (Hinze, 1988). The management team is duty bound to create safety awareness throughout their organization (Choudhry and Fang, 2008). But the management seemed non-interested in emphasizing the need of safety practices among their workers (Farooqui and Arif, 2009). Owner and consultant do stress safety before work

commences, but as the work progresses their concerns for deadlines becomes a priority and they tend to pay less attention to safety (Farooqui et al., 2008).

Moreover the works of Khan et al. (2013) indicate that there is large gap between safety perception of labor and management. The management if committed properly towards safety can reduce this gap and can improve performance of labor. As different studies shown that workers perform more safely when they are properly oriented to the job; when they are not placed under undue pressure; and when they are respected as individuals (Hinze, 1988). Extending the research of Khan et al. (2013) which correlate the perceptions, commitment and attitude of both labor and management, this research objective focus on the significance of management commitment towards safety and how it can improve construction safety.

2. Research Objectives and Scope

In the light of above literature, the research objective is to study the significance of management commitment towards safety in construction industry of Pakistan.
This research is limited to building construction sites of Karachi and some sites of interior Sindh.

3. Research Methodology

The research methodology consisted of steps which start with reviewing the relevant literature, questionnaires making, observation surveys, Research analysis and finally development of conclusions and recommendations. These steps are explained as follows:
In the first step, literature review was done to find out the relevant information on management commitment towards construction safety and to develop observation questionnaire for survey.

This was followed by designing of two questionnaires. The first questionnaire comprises of 20 statements related to "Management Commitment and Support", which is for management respondents. The second one is for labor respondents, which include 23 statements. Out of this 23, twenty statements are from first questionnaire, so that cross check can be done between labor and management statements. The remaining 3 statements are related to behavior of labor and used to predict how management commitment is correlated with labor behavior. Respondents were asked to endorse the statements of questionnaire using a five-point Likert-type scale (from 1= "strongly disagree" to 5= "strongly agree").

In the third step, survey was undertaken by a team that collected data from different construction sites of Karachi and interior Sindh. The survey covered 45 sites in total. From each site 5 labor and 1 management questionnaire were filled. This is summarized in Table: 1. Finally analysis was done on collected data and conclusions and recommendations were drawn.

3. Analysis and Discussion

The data collected from 45 sites was analyzed utilizing the statistical computing package SPSS (Statistical Package for Social Science) version 17.0. The test conducted includes:
1. Cronbach"s Coefficient Alpha
2. Hypothesis test using One-Sample T-test.
3. Correlation Test
4. Kruskal-Wallis Test

3.1 Assessment of Data Reliability and Validity

The reliability and validity of data was assessed Prior to data analysis using Cronbach"s Coefficient Alpha Method. The data was found to be reliable shown in Table: 2.

3.2 Hypothesis testing

Hypothesis testing is done by One-Sample T-test. The hypothesis made for management respondents is if $\mu>0.05$, the management is committed to safety otherwise not. The results showed that this hypothesis is true for all the variables. Management agreed on that they are committed to safety. To cross check whether management is right or not hypothesis test also apply on labor respondents. The hypothesis made for labor respondents is if $\mu>0.05$, the management is not committed to safety. This hypothesis turns out to be true. So, we interpret that management said that they are dedicated to safety, they provide safety manuals, motivates trainings etc. But reality is they are not; as labor are disagree on this.

3.3 Correlation Test

Correlation analysis is done to check how significantly management commitment correlated with labor behavior. After test, some of the variables results were summarized below in Table: 3.

Labor behavioral statements like labor wear PPE, management provides all safety procedures to them and they are conscious about the safety showed minimum or negative correlation with management commitment variables. This explains that

management commit that they have sufficient resources available for safety. On the other hand labor said that they are not provided with PPE because company lacks resources.

After correlating variables, Management Commitment and Labor Behavior constructs were correlated which is shown in Table: 4.

The correlation coefficient between Management Commitment and Labor Behavior indicates that there is less relationship among them. If management commitment is serious, labor behavior also divert towards safety. But the less relationship clearly illustrate that management is not active to promote safety which results in unsafe performance from labors.

3.4 Kruskal Wallis Test

Kruskal Wallis Test was done on 20 variable of management commitment category to check similarity between the management commitment and labors observation. This test is important in analyzing the safety condition of a construction industry. If the labor observed that management not doing what they committed to do for safety, it illustrate that the unsafe construction is going on.
6th ICEC-2013. The hypothesis for this test is if significance value > 0.05, it means labor observed that management is committed to safety.
After analyzing the significance value of most of the variables was less than 0.05. Most of the variables in the category of management commitment and support found less significant. This showed that management commit that they take safety seriously, take measures to disciplines site labors etc. but labor did not observe these commitments.

4. Conclusion and recommendations

Conclusions of research are; management show concern about safety and says that they are committed towards safety but by cross checking with labors, management statements found to be not true. Management commitment towards safety has very significance effect on construction project and labor. Management is not serious about safety and not performing safety measures like training, development of safety manuals and procedure etc., this result in unsafe construction project and unsafe labor performance. It was observed that labor not ask management to give them PPE and safety procedures because they are practically unaware of these. Management claims that they have maintained safety standards but they stress on their work and time more than safety. So, from all these conclusions we can say that there is need of serious management commitment towards safety. If management become strict and implement safety properly, then the safe conditions on construction industry can be achieved. Furthermore this more research will be conducted to develop a SEM model using factor analysis technique and AMOS software. By this we will have more information and precise results, which can help in better reshaping the construction industry.

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Questionnaire	No. of Sites	Respondents on Each Site	Total Respondents
Management perspective	45	1	**45**
Labor perspective	45	5	**225**

Table 1: No. of Questionnaire

Questionnaire of	Cronbach's Alpha	N of Items
Management	0.906	**20**
Labor	0.807	**23**

Table 2: Reliability Statistics

LB / MC	1	3	6	7	12	13	14	15	16	20
1	.323	.331	-.245	.340	.338	.239	.263	**.201**	**.22**	**.382**
2	.355	.153	-.104	.333	.296	.244	.286	**.170**	**.156**	**.218**
3	.113	.099	-.253	.151	.119	-.040	.212	**.207**	**.083**	**.169**

Table 3: Correlation Matrix Between Management Commitment And Labor Behavior Variables

Construct	MC	LB
Management Commitment And Support (MC)	**1**	**0.331**
Labor Behavior (LB)	**0.331**	**1**

Table 4: Correlation Matrix Between Management Commitment And Labor Behavior Construct

Simulation Analysis of 100 MW Solar Power Photo-Voltaic Plant

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Abstract— the article analyse different configurations of a 100 MV Peak DC Fixed Tilted Polycrystalline Photovoltaic (PV) Solar Power Plant. The article first defines the general layout of the plant than it outlines certain fixed parameters such as plant location, its weather data, wiring losses and soiling losses etc. The aim of the article is to show how certain fixed design parameters such as PV module selection, Inverter selection and distance between the arrays can effect the production loss or in other words the Performance Ratio (PR) of the plant. for this purpose a series of simulations have been carried out which are described in detail in the article.

I. Introduction to General Solar PV Power Plant Design

A Solar PV Power Plant is made up of three major sections i.e. DC power, AC power and control and monitoring equipment (SCADA), as shown in Fig 1.1.

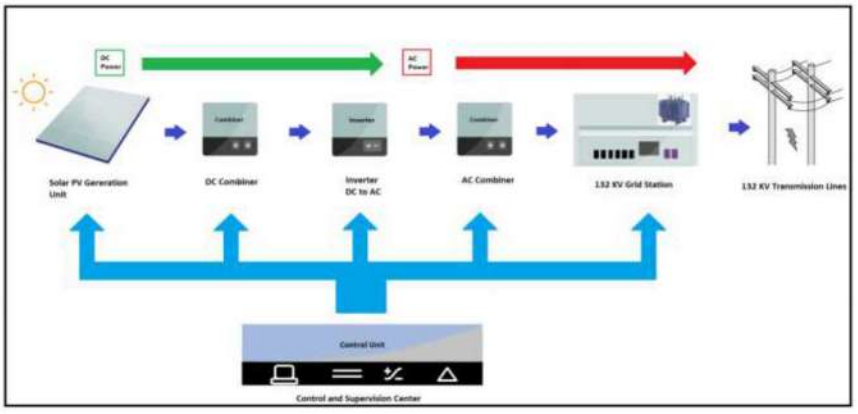


Figure 1.1: Shows general structure of PV plant.

DC stands for direct current all power systems components that process direct current are part of the DC subsystem of the plant. Following are the major components of an DC power system:

Photo-Voltaic (PV) Module:
Major part of any solar PV plant consists of PV module, which is the main generation unit; it is the electrical component which converts solar energy into electrical power. There are different types of PV module technologies. The types that can be considered for this project are polycrystalline (12%-17% efficiency), mono-crystalline (12%-16% efficiency) and Thin-film (6%-8% efficiency)[1]. For this study Polycrystalline silicon is preferred because of its robust nature.

DC Combiner Box:
DC Combiners box is a component that combines the DC current from the PV modules. This component can be avoided if the inverter chosen for the Plant Design has an inbuilt DC combiner functionality [1].

Inverter:
Inverter is the equipment that converts DC power to AC power and is an integral part of any PV plant. Features such as MPPT (Maximum Power Point Tracking), multi-power input and high

conversion efficiency are very important while sizing the component in the design.

AC power systems include all the components that use or process alternate current. Following are the major components of an AC power system:

AC Combiner Box:

AC Combiner box is a component that combines the AC current form the Inverter. This component can be avoided if the inverter chosen for the plant design has an inbuilt AC combiner functionality [1].

132 kV Substation:

In the Solar Plant, the power generated has to be conditioned in-order to meet the requirements of the National grid that is 3 phase, 132KV and 50 Hz power standard before evacuating to main grid lines. For compliance with the power standards a power grid station has to be built this station includes components such as CT, PT, DS and power TIF etc. [2] [3].

SCADA:

Unit control consists of Supervisory Control and Data Acquisition System (SCADA) integrated with weather station and solar PV plant components.

The control system will be capable of monitoring and reporting the desired information and time duration as and when required, displaying on LCD, and detecting string level panel faults such as hot-spots on an interval of one minute [4].

Table 1.1

	GlobHor	BeamNor	T Amb	WindVel
	kWh/m².mth	kWh/m².mth	°C	m/s
January	102,3	107,7	13,5	2,0
February	124,0	123,8	17,8	2,3
March	179,7	163,4	23,2	2,6
April	196,5	148,9	30,2	2,6
May	208,5	127,9	36,5	2,7
June	190,3	94,3	39,4	4,2
July	181,1	81,9	39,0	3,4
August	184,8	117,4	36,8	2,9
September	175,3	136,6	32,9	2,3
October	160,2	161,5	27,8	2,1
November	115,1	110,5	22,2	1,9
December	103,0	106,0	15,5	2,3
Annual average kWh/m²*a	1920,8	1479,7	27,9	2,6

II. Simulation Of Parameters and Equations

In order to build better understanding of how the PVSyst simulates losses and power for Solar PV systems, PV characteristics equations have to be understood. Photovoltaic (PV) panel change its characteristics with the applied solar radiance in the form of voltage and current. The key identifiers of any solar panel are short circuit's Current and open circuit voltage. PV panels power behaviour can be explained by a reversed biased current as shown in figure 1.2 (a). Whereas its power versus voltage and current versus voltage characteristics are shown in figure 1.2 (b) these depend on load and temperature characteristics [5].

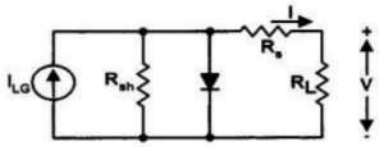
The characteristic equation for this PV model is given by :

$$I = I_{LG} - I_{os} \times \{\exp[q \times (V + I \times R_s)/(A \times k \times T)] - 1\} - (V + I \times R_s)/R_{sh} \quad (4)$$

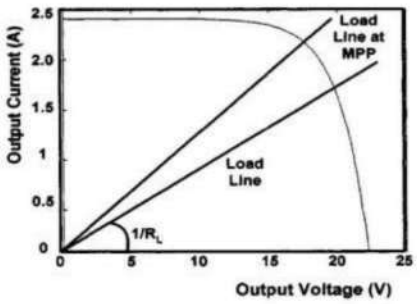
$$I_{os} = I_{or} \times (T/T_r)^3 \times \exp[q \times EGO \times (1/T_r - 1/T)/(B \times k)]$$

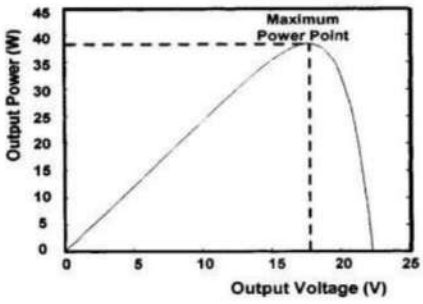
$$I_{LG} = [ISCR + KI \times (T - 25)] \times \lambda / 100$$

Figure 1.2: (a) PV module equivalent circuit (b) Maximum power point characteristics of PV cell [6].



(a)





(b)

The simulations on PVsyst have been done by considering certain fixed parameters. The first and most important parameters are the location and weather data of the PV-Syst model. All the weather data used is from Solar GIS and has been generated on hourly bases for Bahawalpur location (Table 1.1)[7].

The main focus here is to know how the changing of certain parameters in the design can effect the over-all PR (Performance Ratio) of the system. For this analysis certain values have been assumed these values are stated in the Table 1.2.

Table 1.2

Parameter	Value	Unit
Constant Loss Factor	29.00	W/m2k
Wind Loss Factor	0.90	W/m3k/m/s
Global Wiring Resistance	0.08	m0hm
STC Loss Fraction	2.00	%
Volage Drop Across Series Diode	0.00	%
Iron Losses of Transdformer	0.1 Per 98.61 kw	%
Module efficiency loss	0.20	%
Mismatch Losses	1.00	%
Annual Soiling Losses	2.00	%
Fixed Tilt Angle	29.00	%

III. Pv-Syst Simulation

A series of simulations have been carried out for the in-depth analysis of the power plant, the simulations are in three parts. The first part looks at the effect of changing the Polycrystalline Photovoltaic modules of different power specifications and identifies major areas because of which PR changes, the second part highlights at the effect of changing inverters on the overall PR and the third analyses how changing the distance between rows effects the shading losses.

It was observed by changing PV modules that the different types of PV panels can effect in mainly 4 areas that are PV irradiance loss, temperature loss, DC ohmic loss and AC ohmic loss (Table 1.3). The PV Irradiance losses and PV Temperature losses are due to different types of Solar cell that are being used in the simulation. For the case selected the panel irradiance loss increases with increase in power. However the temperature losses reduce this is mainly due to the fact that for more efficient cells the current collectors are designed and made up of materials that dissipate more heat and have high conducting efficiency. DC and AC ohmic losses are not directly related to the module however they are more in line with the DC and AC wiring design and type. These losses are although simulated by PV-Syst can vary significantly on the type of design actually selected.

Table 1.3

Panel Model	JAP6 (JA SOLAR)	JAP6 (JA SOLAR)	JAP6 (JA SOLAR)
Panel Size	250 W	255 W	260 W
Soiling	2	2	2
PV Irr. Loss	0.9	1.4	1.7
Temp. Loss	11.4	11.5	11
DC Ohm Loss	1.6	1.6	1.7
AC Ohm Loss	2.2	2.1	2.2
Performance Ratio	75.5	75.1	75.4

Three simulations have been carried out to see the effect of changing the inverter, on the over-all PR ratio (Table 1.4). It was found that the main losses effected by inverters are inverter operational losses, and AC ohmic losses. Inverter ohmic losses are due to characteristics of the inverter. AC ohmic losses are contributed by other design factors such as the position of inverter and transformer in the main layout, the wiring diameter and length.

Table 1.4

Inverter	SG500MX	SG250K3	SG500KTL
MPPT Specs	500-820 V	450-820 V	450-820 V
Inverter Loss During Ops	1.5	2.9	1.5
Inverter Loss Due to Voltage Thershold	0	0	0
AC Ohmic Loss	2.1	2.1	2.2
Performance Ratio	75.6	74.4	75.5

Distance between two arrays will highly effect the shading losses of the PV plant. For the purpose of investigating the effect of shading losses, a fixed tilt of 29 Degree with a ground fixed configuration i.e the mounting height is assumed to be at zero level from the ground has been considered. It was found that by increasing the distance of the PV arrays the shading losses reduced mainly due to two factors that is diffusion and Albedo. As the distance increases the effect of these two factors decreases non-linearly causing the over-all shading loss to reduce (Table 1.5).

Table 1.5

Array Dist. (m)	Diffusion fact.	Albedo	Over all Loss
3.8	0.044	0.572	3
4	0.04	0.567	2.6
5	0.028	0.539	2
6	0.021	0.511	1.7

IV. Conclusion

In the article after a series of simulations it was found that similar types of PV technology modules of the same company can effect the PR of the over plant if the power production capacity of the module has been changed and it should be selected by keeping in mind the site weather conditions as different panels have different temperature losses. In case of simulations relating to inverter it is concluded that the inverter losses are mainly depend on the type of inverter and are not influenced by external weather factors. In the last series of simulations it was determined that increasing the distance between the arrays will lead to a non-linear decrease in shading losses.

Acknowledgment

Syed Raza Ali Zaidi

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Courtesy by Dawn

Studyof melting Glaciers Worries meteorologists

ISLAMABAD:

Meteorologists worried at the depletion of glaciers in Pakistan studied six glaciers in Karakorum Range recently, and the result have made them worry even more. "All of them were found melting at a faster rate. The changing climate is taking a heavy toll on our glaciers," Chief Meteorologists of Pakistan Met Department (PMD) Dr Ghulam Rasul told Dawn. And the disaster awaiting the nation can be imagined as depletion of glaciers in northern Pakistan during the last decade had been consistent with the rising temperature. Experts say the study showed that the Hinarchi glacier, which had retreated 800 metres in the 32 years between 1977 and 2009, retreated another 300 metres during the next five years. Similarly, the Baulter glaciers which had retreated 1,500 metres, shrank another 400 metres by 2014. The future of the Barpu glacier looks gloomy as it has shrunk 640 metres since 1977. Dr Rasul explained that due to rising temperature the glaciers had been losing their ice mass at a faster rate than ever before. The last 15 years witnessed a big escalation in the thermal regime of glaciated and snow covered region of Pakistan. We recorded more than one degree Centigrade increase in temperature which triggered the formation of glacial lakes and the phenomenon of GLOF – glacial lakes outburst floods – occasionally high river flows, land lips and slides," he said. The Met Department study suggests that accelerated melting of glaciers, together with intense monsoon rains, brought river flooding downstream. It notes that formation of glacial lakes inside the glaciers is now "fairly frequent." High temperatures, glacier movement or weakening ice walls can cause them to burst open suddenly, flooding areas downstream. Sometimes, glacial lakes mysteriously appear and disappear suddenly. A massive lake on the Hinarchi glacier, which PMD team started studying in 2012, disappeared suddenly in August 2014.

Similarly, a massive lake was discovered at the mouth of Liligo glacier in the summer of 2013 that did not exist in 2010 when it started receding. "Since 2010, Pakistan has regularly suffered floods caused by intense monsoon rainfall, which weathermen had been predicting will further intensify. The flood in 2010 and 2014 inflicted historic losses," he recalled. The 2010 floods left no region of the country untouched. It devastated Punjab, Azad Kashmir, Gilgit-Baltistan, Khyber Pakhtunkhwa, Baluchistan, and Sindh to various degrees. Floods visited Baluchistan and Sindh in 2011, Punjab and Sindh 2012, Azad Kashmir, Khyber Pakhtunkhwa, Punjab and Sindh in 2013 and Azad Kashmir, Punjab and Sindh in 2014. Pakistan has been holding the top position among the 10 highly vulnerable nations to climate-induced disasters, according to the organization, German watch. "It is not a matter of pride rather a moment to think about a day when it could be declared as disaster resilient one. Unfortunately, so far no serious thought has been given to mitigate the disaster risk expect routinely delivering relief goods and distribution of cheques, which poor economy of Pakistan cannot afford.

AMAZING - WHAT IS A MILLION TIMES THINNER THAN HUMAN HAIR AND 200 TIMES STRONGER THAN STEEL

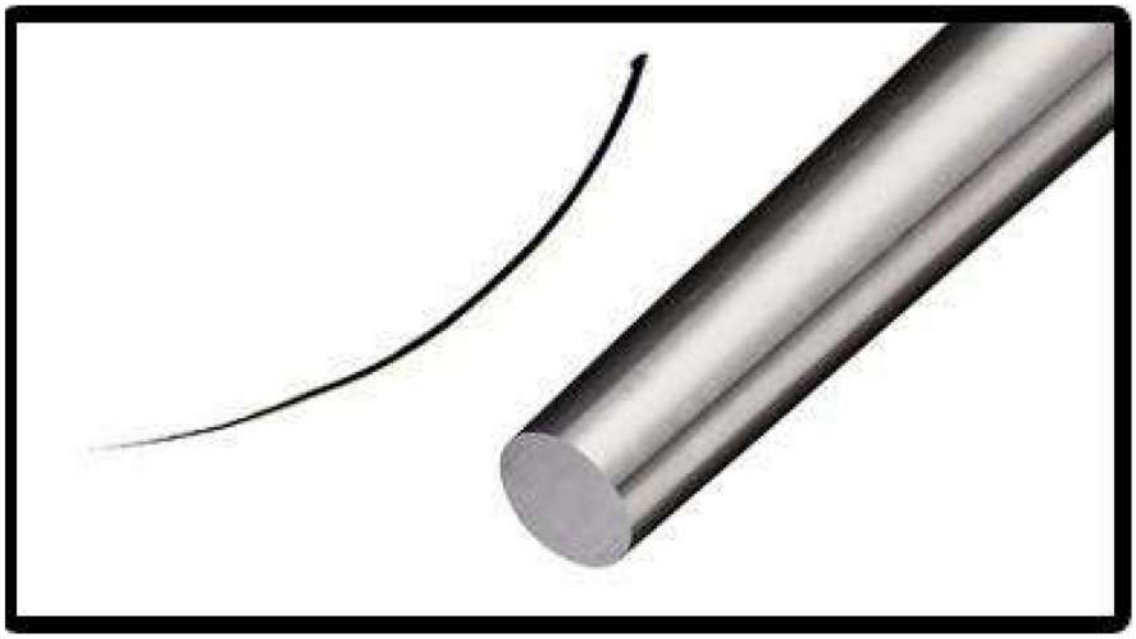
Many of you might have read about a substance which was discovered in Manchester University by two Russian scientists who had emigrated from Russia to Britain. They named this wonder substance Graphene. Their discovery was ten years ago and they received Nobel Prize for this discovery in 2010.

It is the thinnest material known because it forms sheets of crystal just one atom thick. It is an excellent conductor of electricity.

It is useful in electronics such as bendable mobile phones and cameras. In a recent study in the Journal Nature recently it is being predicted that from Atmosphere hydrogen will be extracted and pumped through positively charged hydrogen protons across the one atom thick membrane by applying a small electric current. This could dramatically increase the efficiency of fuel cell which could generate electricity directly from Hydrogen. This breakthrough raises the prospect of extracting Hydrogen fuel from air burning it as carbon free source of air to produce electricity and water with no damaging waste products. As the thin one atom cell thick membrane only allows hydrogen atoms to pass through this will end up as reservoir of hydrogen on One side of the thin membrane. From this Hydrogen reservoir Hydrogen will be burned in the same fuel cell and make electricity. This will open up a new source of clean energy.

Ever since its discovery Graphene has astonished scientists with its huge implications. In effect you push through air from atmosphere and get electricity. Before this paper it would not even be speculation but science fiction according to the author Professor Andre Geim who discovered Graphene along with another scientist.

Mustafa Haqqani



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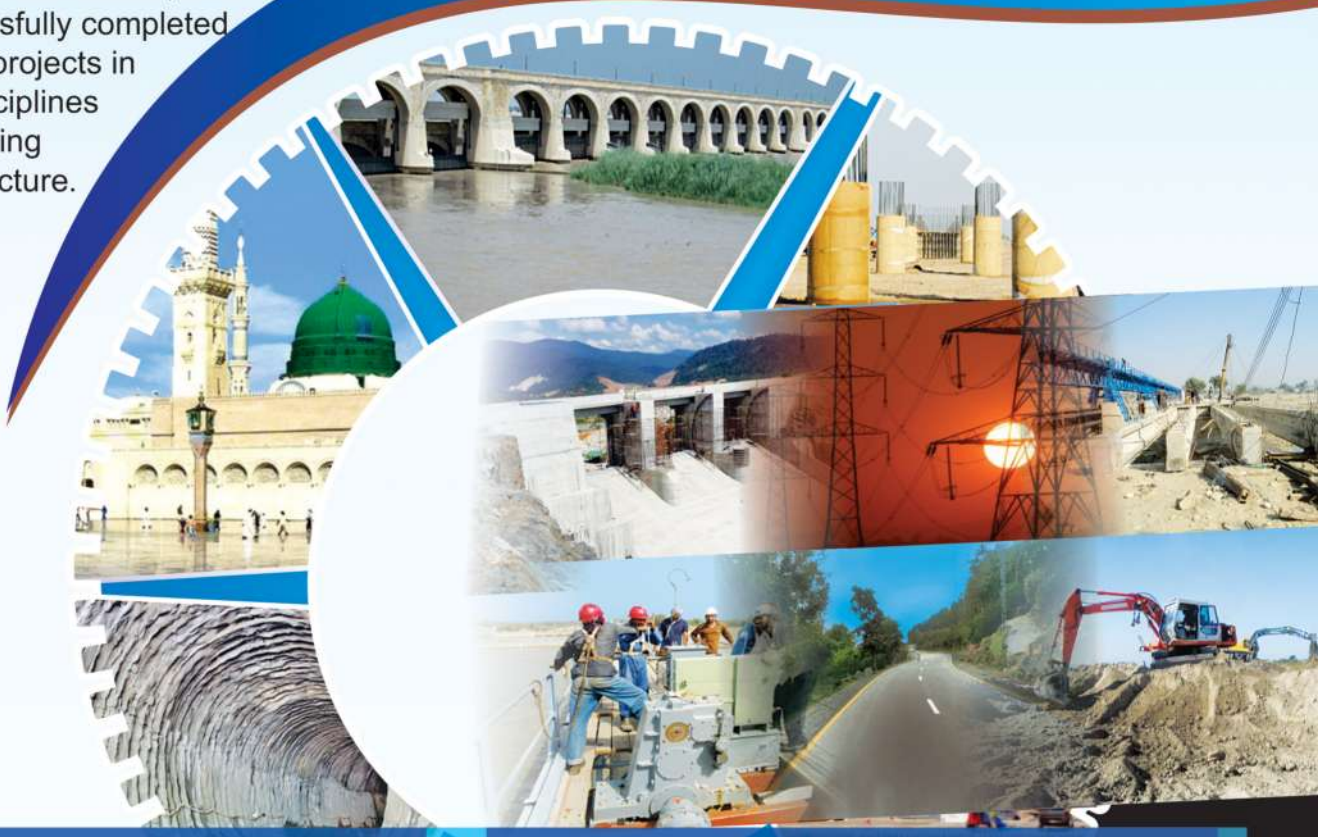

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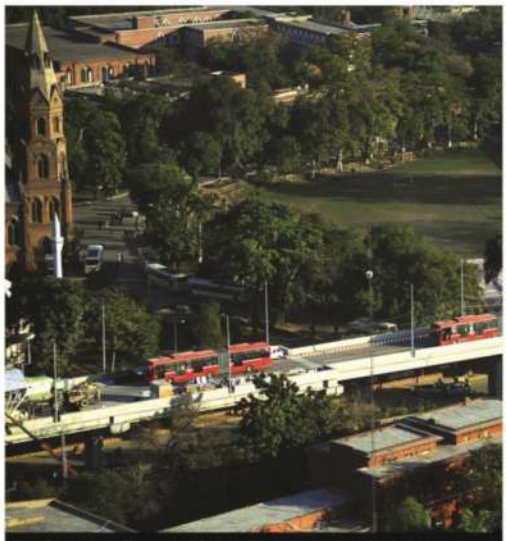
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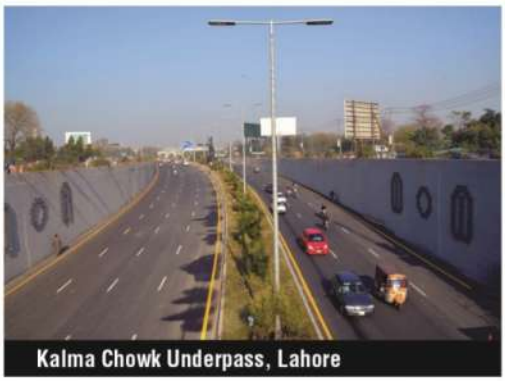
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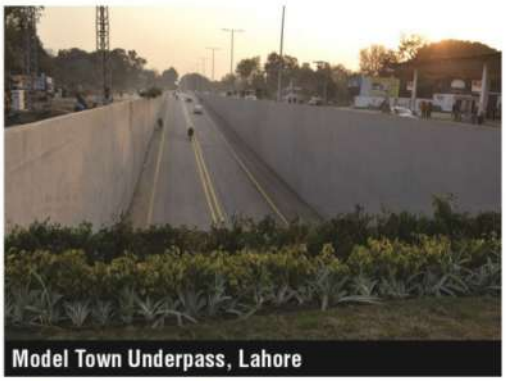
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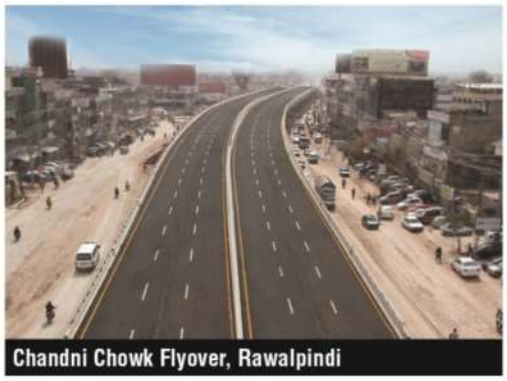
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