Sustainability Tomorrow in Construction Materials and Technologies

Abeer Samy Yousef Mohamed and Dina Ahmed Ahmed El-Meligy

Abstract—Buildings, infrastructure and the environment are inextricably linked. Energy, materials, water and land are all consumed in the construction, operation of buildings and infrastructure. These built structures in turn become part of our living environment, affecting our living conditions. It is therefore important to explore environmental design and development techniques in order to design buildings according to be sustainable, healthy and affordable. Until recently, much of the development of building materials has predominantly focused on producing cheaper, stronger and more durable construction materials.

The building sector is responsible for creating, modifying and improving the living environment of humanity. But the basic problem here that are construction and buildings have considerable environmental impacts, consuming a significant limited proportion of resources in the planet including energy, raw material, water and land.

The main aim of this paper is looking at appropriate tools and concepts for the design and assessment of the sustainability impacts of materials, components and technologies used in buildings and their construction, then achieving how to realize Sustainability in several types of construction projects. Hence, this paper is intended to highlight some projects that show new innovative ways of achieving sustainability of construction materials and technologies.

***Index Terms*—Construction materials technologies, built environment, construction industry, sustainable construction**

I. Introduction

Sustainability' is becoming a central concern for us all. It is a concern that has grown out of wider recognition that rising populations and economic development are threatening a progressive degradation of the earth's resources [1]. The concept of sustainability in building and construction has evolved over many years. The initial focus was on how to deal with the issue of limited resources, especially energy, and on how to reduce reverse impacts on the natural ecosystem. Emphasis was placed on technical issues such as materials, building components, construction technologies and energy related design concepts. More recently, an appreciation of the significance of non-technical issues has grown. It is now recognized that economic and social sustainability are important, as are the cultural heritage aspects of the built environment [2].

Sustainability in construction is all about following suitable practices in terms of choosing materials, their sources and construction methodologies as well as design philosophy, so as to be able to improve performance, decrease the environmental burden of the project, minimize waste and be ecologically friendlier, take into consideration environmental, socio-economic and cultural values. Specifically, it involves issues such as design and management of buildings performance, materials, energy and resource consumption - within the larger orbit of urban development and management as well [3].

All materials are ultimately derived from the bio-geo-sphere. They are everything between the take and waste and are the key to sustainability. The choice of materials for construction controls whole of life cycle impacts such as emissions, gross take, properties of wastes returned to the bio-geo-sphere, use of recycled wastes and their own recyclability. Materials also strongly influence lifetime energies, user comfort and durability [4].

II. Defining Sustainability

In fact, sustainable development is not just another social or environmental policy; it is a business opportunity too. Reviewing their activities with a more sustainable perspective, construction businesses could go beyond reducing detrimental environmental impacts. In many cases they will also benefit from improved and more profitable operation, as well as an enhanced reputation both in the community and with customers. An enduring long-term regard for 'sustainability' as a way of business is essential to the future of the construction materials and technologies, also could benefit individuals as well as contributing to global solutions. Disregarding social and environmental values is not only damaging to the planet, but also will ultimately inhibit the healthy progression of business. As the sustainable construction task force have asserted, "Sustainability issues are of critical and strategic importance to business....Ignore sustainability and your reputation is on the line."

The construction materials , technologies and use of buildings impacts substantially on our environment is currently contributing significantly to irreversible changes in the world's climate, atmosphere and ecosystem. Buildings are by far the greatest producers of harmful gases such as CO_2 and this 'eco footprint can only increase with the large population growth predicted to occur by 2050 [5]. What 'sustainability' means is adapting the ways we all live and work towards "...meeting needs, while minimizing the impacts of consumption, providing for people of today and

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not endangering the generations of tomorrow...". The UK Government has set out its approach to sustainable development in a White Paper, which identifies four objectives:

1) Social progress that recognizes the needs of everyone;
2) Effective protection of the environment;
3) Prudent use of natural resources;
4) Maintenance of high and stable levels of economic growth and employment.

This approach emphasizes that a 'joined up' attitude to all aspects of sustainability is important, as each area overlaps and relates with the others. However, the environmental and resource elements of this sustainability equation are particularly important for the construction industry which draws materials directly from natural resources, uses highly energy intensive processes, removes land from other uses, and is responsible for designing and making products that have a lasting effect on the needs of their users [2].

III. How Can the Construction Materials and Technologies Have More Sustainable Approach?

The construction industry is a vibrant and active industry. The building sector is responsible for creating, modifying and improving the living environment of humanity. On the other hand, construction and buildings have considerable environmental impacts, consuming a significant proportion of limited resources of the planet including energy, raw material, water and land. Therefore, the sustainability of the built environment, the construction industry and the related activities is a pressing issue facing all stakeholders in order to promote Sustainable Development. The new millennium is challenging practitioners and researchers with the sustainability of the built environment and the construction industry. Still, sustainable construction adopts different approaches and is accorded different priorities in different countries. It is not surprising that there are widely divergent views and interpretations between countries with developed market economies and those with developing economies. Countries with mature economies are in the position of being able to devote greater attention to creating more sustainable buildings by upgrading the existing building stock through the application of new developments or the invention and use of innovative technologies for energy and material savings, while developing countries are more likely to focus on social equality and economic sustainability, [6].

As long as sustainability in construction projects is generally achieved by, [3]:

1) Defining clear goals sympathetic to sustainability issues.
2) Concentrated effort at design stage to achieve these goals.
3) Focusing on decisions like site selection, building layout, design,… etc.
4) Choosing the right materials which are recyclable after their useful lives.
5) Choosing the right methods of construction in terms of energy and resource efficiency.
6) Creating an efficient and integrated building envelope harnessing the gifts of nature.
7) Integrating HVFAC and electrical systems.

So that the starting point for all members of the construction industry that wish to approach sustainability as a business opportunity - from big developers to small companies and those who refurbish existing buildings - must be to re-think their operations in four key areas:

1) Energy: reducing energy consumption, being more energy efficient and using renewable energy and 'alternative technology'.
2) Materials: Choosing, using, re-using and recycling materials during design, manufacture, construction and maintenance to reduce resource requirements.
3) Waste: Producing less waste and recycling more.
4) Pollution: Producing less toxicity, water, noise and spatial pollution.

This will lead on to a re-assessment of best practice in each area, with cumulative benefits from overlapping improvements between the areas. The implementation of those results could improve profits and investment [3].

In this paper we focus about one of previous key areas "construction materials & technologies", which will contribute towards a sustainable future for the construction industry. Until recently, much of the development of building materials has predominantly focused on producing cheaper, stronger and more durable construction materials. More recently attention has been given to the environmental issues in manufacturing, using, disposing and recycling of construction materials. Sustainability of construction materials brings together a wealth of recent research on the subject [7]. Materials are the key to sustainability in the built environment and innovative new materials will allow architects and engineers to build structures that have greater value as they are more pleasing to use, live in or look at, healthier for us and much more sustainable. Huge quantities of materials are used. Their choice profoundly affects many value properties relevant to sustainability including weight, embodied energies, fuel related and chemical emissions, lifetime energies, user comfort and health, use of recycled wastes, durability, recyclability and the properties of wastes returned to the geosphere-biosphere, [4].

A. Sustainable Construction Metrics

The construction industry uses a major part of the 6 billion tons of industrial raw material that we deplete from the earth's resources each year. Environmental impacts are tremendous but hard to measure objectively for each single construction project. The trend in sustainability evaluation in the world is toward Life Cycle Assessments for each material used in a particular building, i.e., a micro-level analysis. Few if any attempts have been made to evaluate environmental or sustainability impacts at larger scales. But LCA based methodologies are far from operational at this point, mainly because of the following reasons [8]:

1) An LCA has to address a wide range of environmental aspects, usually split up into three domains: pollution (emissions of hazardous material into the environment), depletion (use of biotic and a-biotic raw materials), and impairment (all negative structural effects in the environment). Many of these aspects are very hard to quantify in an objective way [9].
2) Combining different aspects of the LCA domains into one integral eco-rating is very difficult, since there are

no reliable indicators to distinguish the relative importance of the various indicators. Moreover, emergent properties on the system scale are an important parameter in the determination of relative importance. Not surprisingly, so-called eco-labeling of products in other industrial sectors is usually done on the basis of a very narrowly defined LCA method, (e.g., pollution through acidification (NH3) and eutrophication (phosphates), as in the case of detergents). Needless to say, such disparate indicator labeling does not make much sense for building products.

3) The underlying data for an LCA is usually very hard to obtain, especially objective, quantitative data about emissions, wastes and energy inputs in the production process due to proprietary information concerns by profit-driven corporations.

B. Sustainability in Construction Technologies

The direction is clear; technology can help us change the techno process. By doing so the process becomes more economic and thus self propelled with less government intervention. Technology can make it possible to achieve a far greater measure of sustainability, to economically reduce, re-use and recycle. The potential multipliers from spending on research and development are huge [4].

Identifies technologies which can be used during construction to improve efficiency and reduce waste [10].

Such as trenchless technology-a pilot bore is made and piping is pulled back through pilot hole. Then additional sections of pipe are connected and pulled in, in addition to avoid damage to tress and reduce public annoyance by using trenchless technology for underground substructure work. See Fig. 1.

Fig. 1. "Open cut", a well established technique, damages to trees

IV. Materials

Around 50% of all global resources go into the construction industry, with a specific example being that 70% of all timber is used for building. (Edwards and Hyatt, see further read list for details). It is therefore very important that a sustainable approach to choosing and using materials is adopted, in order that the industry can meet the target of, '...providing for people of today and not endangering the generations of tomorrow...'.

The environmental and economic benefits of sustainability are inherently linked when considering building materials, due to the long-term financial advantages of recycling, using recycled products and sourcing heavy materials locally [9].

A. How to Choose and Use Materials in a More Sustainable Way

A variety of decision-aiding tools exist, which can help to evaluate the environmental cost of a manufactured product in the context of social and economic benefit. These include Life-Cycle Assessment, Eco-Labelling and Embodied Energy Audits, all of which could help when choosing materials and suppliers to assess the balance between short-term costs and long-term environmental, social and financial benefits [11].

There are also some other considerations to take into account when re-evaluating the way in which materials are used in construction:

1) What reserves are left of our materials, and how can their complete successive depletion be prevented?
2) What are the pollution impacts of the manufacturing process involved with creating new materials?
3) How can existing materials be recycled? (roof tiles, bricks, timber, etc.).
4) How can more recycled and reclaimed materials be used effectively in design and construction?
5) Could materials be designed and used in a way more conducive to re-use?
6) How much energy is consumed in the transport of materials? (try sourcing heavy, bulky materials locally and lightweight materials globally).
7) Can more prefabricated components be used? (reduces waste and dust on site).
8) How can more natural building materials be incorporated practically into design and construction? (earth products, stone, timber, lime, organic insulation, and water-based paints).
9) How can more low maintenance materials be used in order to reduce further energy and resource use in the future of the building?

B. Building Using More Durable Materials

Building materials are not as durable as they could be but in the future it would make sense to improve durability, not only because buildings that last longer do not have to be replaced as often, but because if we are to incorporate wastes in building materials the less often they are recycled and these wastes potentially concentrated the better. The Tec Eco cement technology substantially improves the durability of concrete. We need to think at the supply and waste end when we design building materials – not just about the materials utility phase in the middle [12]. Making the built environment not only a repository for recyclable resources (referred to as waste) but a huge carbon sink is an alternative that is politically viable as it potentially results in economic benefits. By including carbon, materials are potentially carbon sinks; by including wastes many impacts at the end of the supply chain are solved. Toxic and hazardous waste technology and concrete technology will merge because the fact is the standards on risks associated with using wastes and the pressures to do so are both rising rapidly. Even now it no longer makes sense to just encapsulate waste materials in a concrete and bury them. They have to be so safe that we may as well make useful product out of them [11].

Tec Eco technology will make concretes more sustainable and, as in the long run, sustainability and profit are actually the same direction, there is nothing to fear from them! [12]. Also sustainability is in all materials but depends in how we could use them, see Fig. 2.

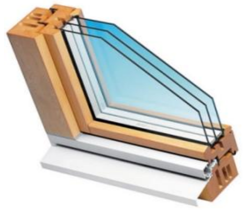

Fig. 2. Solid wood passive-house-window U-value (window): 0, 78 W/m^2K

C. Future Construction Materials

Over the past 50 years, the typical strength of structural steel has increased 40 percent, reinforcing bar by 50 percent, and concrete by as much as 100 percent. These increases will continue.

Concrete reinforcing bars [13]: which typically have a strength of 60 ksi (kilopound per square inch), are now starting to be substituted in limited applications with bars having strengths of 75 ksi and even 100 ksi. These higher-strength bars will be used much more frequently in the future because in most applications, the tonnage of rebar needed for a particular building decreases in direct proportion to the increase in strength. The technology already exists to dramatically increase the common concrete strengths of today, but use of this advanced material is often hampered by the congestion caused by the amount of rebar needed to reinforce it. However, stronger rebar takes up less volume, which results in less congestion so stronger concrete can be used. Expect to see typical concrete strengths in columns and shear walls increase by 100 percent. Structural steel strengths will also increase for columns and truss members. There have already been very limited uses of steels as strong as 100 ksi, double the 50 ksi common today, and these stronger materials will find increased applications in the years ahead. Lastly, many new kinds of products will be developed to offer increased sustainability, economy, fire-resistance and/or durability. For example, within the last year, translucent concrete has been introduced. It uses a glass aggregate to allow light to pass through the material. Say goodbye to the expression “solid as concrete”!

D. Design Method and Tools for Sustainable Construction Materials

The environmental and economic benefits of sustainability are inherently linked when considering building materials, due to the long-term financial advantages of recycling, using recycled products and sourcing heavy materials locally [2]. So To educate familiarize individuals to environmentally friendly materials, as well as those which cause the most harm to our environment. A variety of decision-aiding tools exist, which can help to evaluate the environmental cost of a manufactured product in the context of social and economic benefit [5]. These include Life-Cycle Assessment, Eco-Labelling and Embodied Energy Audits, all of which could help when choosing materials and suppliers to assess the balance between short-term costs and long-term environmental, social and financial benefits.

An Example-Ferrocement: A variation of reinforced concrete is another appropriate technology for certain types of constructions. It uses the commonly available, energy intensive materials like cement and steel but in a highly efficient manner thus saving scarce material resources. With an ability to be cast into thin shell elements, Ferrocement opens possibilities which are not possible in conventional brick and concrete. Steve Kohner of flying-concrete has done some exciting construction in this material exploiting the age old, structurally efficient vault shapes. See Fig. 3 and Fig. 4, [3]:

Fig. 3. Ferrocement can be used in exciting ways to make durable, light weight buildings

Fig. 4. A vaulted residence designed and built by Steve Kohner, Mexic

V. An Example: The Future City of Masdar, Abu Dhabi, United Arab Emirates

The project aims to set new standards with a zero-carbon energy supply system. Masdar City is scheduled to be ready for occupation by 50,000 people in 2016. At the World Future Energy Summit exhibition BASF will have its own stand with the theme “More Efficiency from Less Energy”. [14]. BASF shows methods available today that can cost efficiently reduce energy consumption during the construction and use of buildings, cut carbon emissions and increase living comfort. BASF has an extensive range of products and system solutions in these areas that are modified globally to suit local construction industry requirements, architectural traditions and climate: “Chemical innovations substantially increase the energy efficiency of buildings in all climate zones and significantly reduce greenhouse gas emissions,” said Dr. Bernhard Hofmann, head of BASF’s Construction Chemicals division. “We thus aim to offer our customers in the construction industry the best concepts, economically and ecologically.” Dr. Thomas Weber, Managing Director of BASF Future Business, said: “BASF spends approximately one-third of its research and development budget on projects that help to use energy efficiently and thus protect the climate. Examples are solutions that make it possible to generate and store energy more efficiently or that reduce energy consumption.”

BASF plans to demonstrate the following solutions at the World Future Energy Summit exhibition: Fig. 5. (a, b, c and d). Reducing carbon emissions during concrete manufacture, BASF supplies concrete manufacturers with high performance plasticizers sold under the brand name Glenium Sky. The plasticizers preserve the quality of concrete during transport, make concrete easier to process at the building site due to enhanced fluidity, and produce completed concrete structures that have high strength and a long lifetime. In addition, Glenium Sky reduces carbon emissions during concrete manufacture. Adding Glenium Sky to concrete allows manufacturers to use cement types containing high amounts of carbon neutral supplementary cementitious materials. These materials replace one component of the cement, the so called clinker, which is manufactured in a highly carbon-intensive process. Thus, using Glenium Sky lowers carbon emissions by up to 60 percent. Using Rheomatrix admixtures in combination with Glenium Sky saves even more energy. The admixtures give the concrete self-compacting properties that eliminate the need for high-energy compaction by machine. Versatile polyurethanes – cladding, cooling and coastal protection.

In the Gulf region, the construction and insulation markets offer a large range of opportunities for the high end polyurethane plastics Elastopor H and Elastopir supplied by the BASF Polyurethanes division. Sandwich elements, insulating boards and spray-applied rigid foam are ideal for energy-efficient, uncomplicated construction for industry and housing. Polyurethanes are the materials of choice for cold store insulation and for the cladding around cold air pipes. Rigid polyurethane foam is useful in hot climates for space-saving, efficient building insulation.

The specially developed elastomeric polyurethane system Elastocoast is designed for coastal protection. Elastocoast is a polyurethane-rubble combination that bonds stone layers permanently at selected points in the breakwaters of coastal defense systems. The stone layer created is highly stable, extremely resistant and open-pore. Unlike rigid surface constructions made of concrete or bitumen, the rubble layer clamped by Elastocoast absorbs the energy of impact of incoming water masses and prevents stone surfaces from rupturing.

Neopor saves on energy for cooling;

Neopor is an innovation for the insulation of building exteriors, roofs and floors. Inbuilt infrared absorbents and reflectors give Neopor an insulation performance 20 percent higher than that of other insulating materials, in this manner keeping room temperature constant and helping create a pleasant living environment. Figures calculated by the Passivhouse Institute Darmstadt show that thermal insulation with Neopor significantly reduces the incidence of overheating and the hours of active cooling in warm climatic zones. Depending on the type of dwelling and construction style, Neopor thus cuts cooling energy by at least 30 percent and lowers carbon emissions. The BASF stand will demonstrate Neopor insulating panels and insulating concrete forms (ICFs).

Wall systems for greater energy efficiency;

BASF also presents novel wall systems available under the senergy brand name. The systems are composed of multiple layers for the insulation and protection of exterior surfaces. These solutions enable buildings to be cooled in an efficient manner, so reducing energy consumption. Senergy systems are also decorative and open up new flexibility in terms of exterior design, [14].

Black pigments reduce surface heat;

BASF will also be showcasing black pigments for reducing surface heat: Paliogen, Lumogen and Sicopal. Unlike the soot pigments in common use, BASF's pigments prevent the absorption of the invisible near infrared radiation that accounts for more than 50 percent of incident solar energy. Field tests show that construction materials containing the BASF pigments store only about half as much heat as conventional materials. The pigments have many potential uses in the construction industry, including roof elements, coated exteriors, and plastic window frames. BASF developed an IT program called CoolSim for its customers to ensure optimal surface pigment composition and hence maximize the cooling effect.

Micronal PCM for better indoor climate control;

BASF offers Micronal PCM latent heat storage materials for a better indoor climate control. Micronal PCM consists of microscopic plastic capsules with a pure wax core. The core liquefies above a predefined room temperature, absorbs excess interior heat by a phase change process, and in this way stops the temperature from rising. If room temperature falls, the wax solidifies and the capsules return their heat to the room air. Integrating Micronal PCM into a building concept without air conditioning reduces peak temperatures. With Micronal PCM latent heat storers as an integrated component part of a functional building concept, optimized results with regard to passive overheating protection, stabilization of indoor temperatures and efficient use of surface cooling systems can be achieved. A series of Micronal PCM modified construction materials is already available on the market.

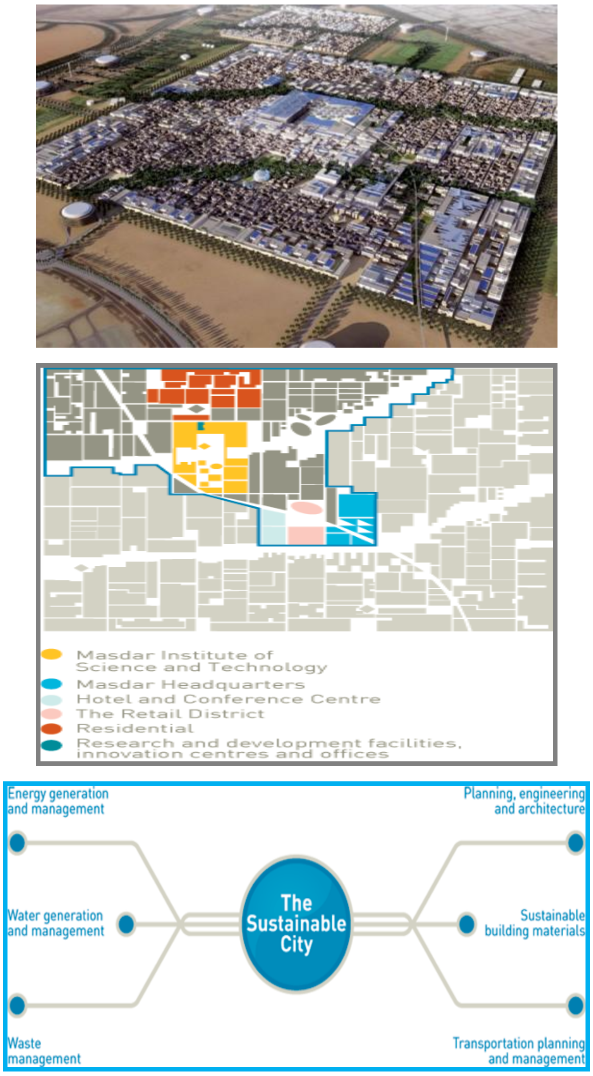

Fig. 5. a) The future city of Masdar, Abu Dhabi, United Arab Emirates.

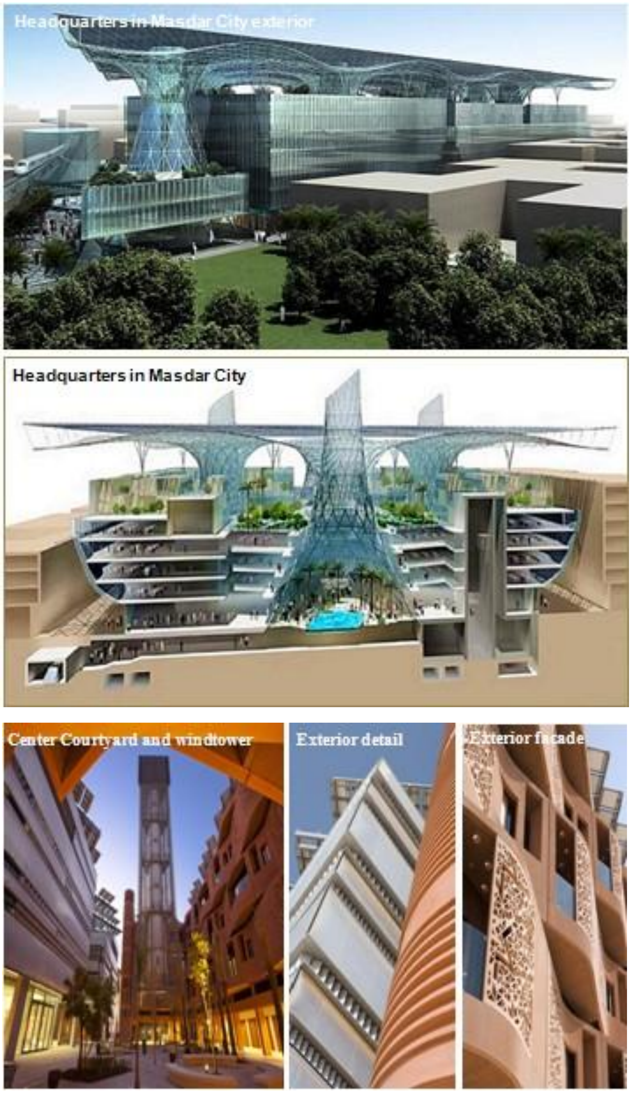

Fig. 5. b) The future city of Masdar, Abu Dhabi, United Arab Emirates

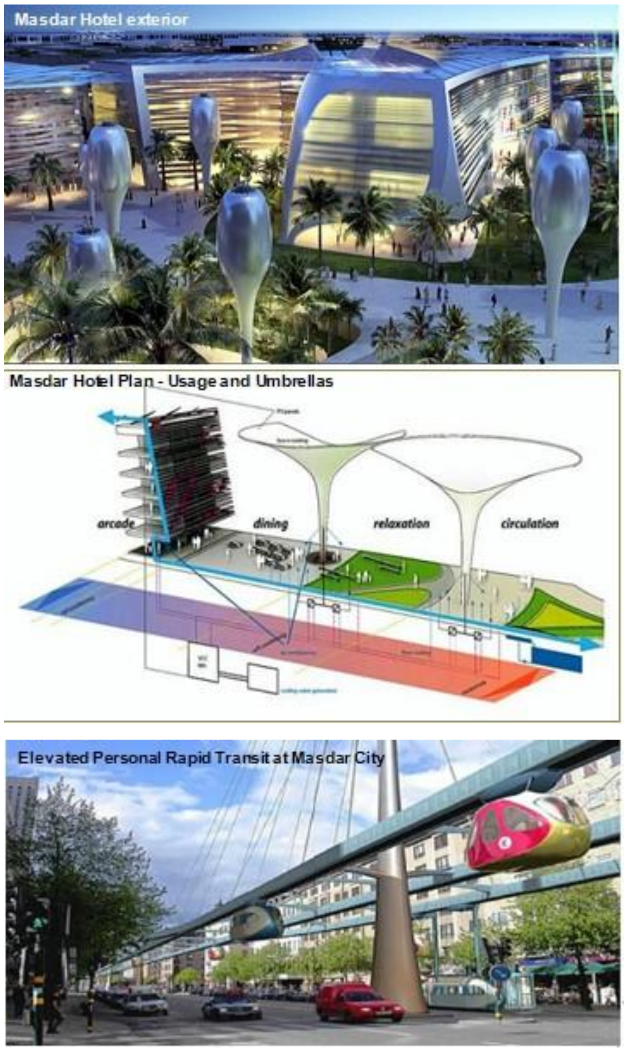

Fig. 5. c) The future city of Masdar, Abu Dhabi, United Arab Emirates

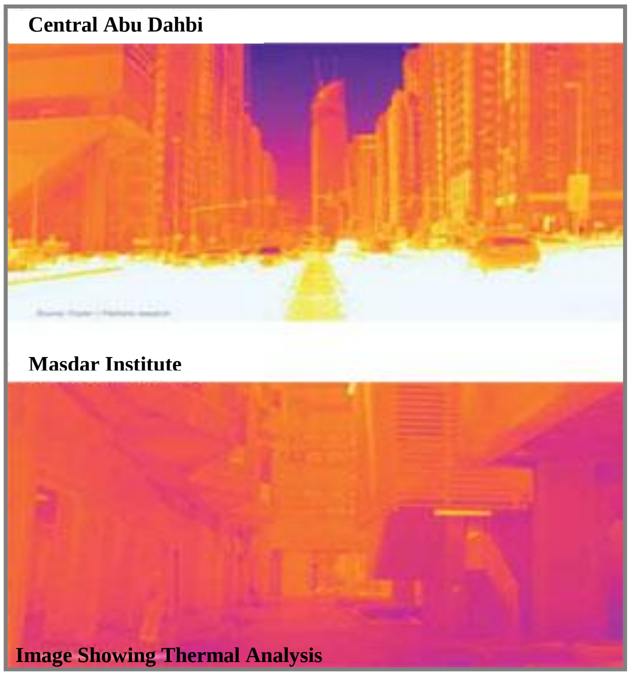

Fig. 5. d) Pictures taken by a thermal imaging camera show the difference in radiant temperature between a typical central Abu Dhabi street and a street in Masdar City. The bright white hot spots of the exposed street, yellow and bright orange show the hottest areas dominate the central Abu Dhabi streetscape, while blues and purples – indicating cooler temperatures, dominate in the Masdar City streetscape. This difference in radiant temperature of up to 20 ℃ is quite an achievement.

VI. Conclusion

The role of materials for greater sustainability is discussed. A number of ways are suggested to make the construction industry more sustainable including reducing the energy it takes to run buildings (lifetime energy), reducing the high level of waste in

Construction, utilizing wastes to make construction materials, reducing emissions during the production of building materials, sequestering carbon by utilizing carbon containing materials and building using more durable materials. There are no economic disadvantages of any of these methods and some; such a reducing embodied energies are clearly economic. Underlying all is technological change, particularly in relation to materials.

Materials are the key to sustainability in the built environment and innovative new materials will allow architects and engineers to build structures that have greater value as they are more pleasing to use, live in or look at, healthier for us and much more sustainable.

Technology can make it possible to achieve a far greater measure of sustainability, to economically reduce, re-use and recycle. The potential multipliers from spending on research and development are

References

[1] S. P. Bingulac, "On the compatibility of adaptive controllers," in *Proc. 4th Annu. Allerton Conf. Circuits and Systems Theory*, New York, 1994, pp. 8-16.

[2] A. Birkshire, "Sustainability and construction," *The Chartered Institute of Building "CIOB"*. United Kingdom. 2008.

[3] S. Tommorow, "Sustainable construction, the CIIITC, centre for excellence in sustainable development," *Construction Research Centre*. 2007.

[4] C. J. kibert, "Sustainable construction," *The First International Conference of CIB TG,* Tampa, Florida, U.S.A. 1994.

[5] A. B. Ngowi, "Creating competitive advantage by using environment-friendly building processes," *Building and Environment.* 2001.

[6] L. Bragança, M. D. Pinheiro, S. Jalali, R. Mateus, R. Amoêda, and M. C. Guedes, "Portugal SB07, sustainable construction, materials and practices, delft university press, centre for excellence in sustainable development," *Constructio Research Centre*. 2007,

[7] J. Khatib, "Sustainability of construction materials," University of Wolverhampton, UK, Woodhead Publishing Limited"WP", Abington Hall, Granta Park, Great Abington, Cambridge, CB21 6AH, England. 2009

[8] G. Augenbroe, "Sustainable construction in the united states of america," *A Perspective to the year 2010, Georgia Institute of Energy*, U.S.A. June 1998.

[9] J. Harrison, (2007). The Role of Materials in Sustainable Construction. ISOS Conference, 14th November Canberra, ACT, Australia Communiqué Downloadable. [Online]. Available: http://www.isosconference.org.au/entry.html.

[10] M. H. Pulaski, "Field Guide for sustainable construction, partnership for achieving construction excellence the Pennsylvania state university-university park, PA," *Pentagon Renovation and Construction Program Office Arlington, VA*. 2004,

[11] R. Spence and H. Mulligan, "Sustainable development and the construction industry," *Habitat International*, 1995.

[12] J. Magnusson, "A beautiful tomorrow for structural engineering? Look for more complex designs and stronger materials in the buildings of the future," *Magnusson Klemencic Associates*. 2007.

[13] M. Atkinson, "Keynote address," *Energy Efficiency Conference*. 2003.

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