Innovation in Structural Construction Material Management for Enhanced Project Performance

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Abstract- The purpose of this study was to review the various types of innovative construction materials that are currently available. The results showed that advances in nanotechnology, the use of mineral admixtures, glass and plastic, biological materials, wood, and other construction materials have all significantly contributed to the growth of innovative construction material discovery and production. Some innovative construction materials have been implemented, and they meet requirements for sustainability, durability, reliability, safety, cost reduction, improving quality, better mechanical and physical characteristics, flexibility in extreme conditions and locations, ease of assembly, and environmental friendliness. The materials used to complete the project accounted for approximately 40% of the project's total cost.

Keywords – innovative construction, mineral admixtures, glass, plastic, biological materials, wood.

INTRODUCTION

One could characterize construction materials as the foundation of civil engineering. In order to improve safety, reduce pollution, make buildings more user-friendly, aesthetically pleasing, and promote a healthy atmosphere, construction materials are used in the development of streets, railroad tracks, aero plane terminals, viaducts, burrows, spans, dams, seaward structures, television towers, water reservoirs, and nearly every other aspect of life on Earth. In construction projects, the cost of the materials used could account for up to 40% of the total project cost. The adage "Necessity is the mother of invention" is frequently used. The human need for a better existence has compelled mankind to develop safer and more comfortable living environments that offer dependability, durability, functionality, and a hint of harmony and beauty. The acceptance of innovative building materials ought to be predicated on meeting certain criteria, including but not limited to sustainability, durability, dependability, safety, cost reduction, enhanced quality, superior mechanical and physical properties, exceptional condition flexibility, ease of assembly, and environmental friendliness. 3D printed sandstone, reinforced concrete consisting of foam, aluminum and bamboo, bio-receptive concrete, bricks built from pollutants, plaited microbial cellulose and super plasticizers are a few examples of cutting-edge building materials. Another example of a successful waste-to-wealth strategy is the manufacture of concrete using fly or pond ash instead of cement and sand. This lowers costs and offers a solution to the problem of transferring combustible waste from power plants. Any construction project's material selection should be determined by the project's needs and suitability. The environment has also been contaminated by some man-made building materials, including concrete, metals, brick, ceramics, and plastics. Both the end user and the construction sector should broadly accept construction materials. When choosing and approving any building material, the financial viability is crucial. It is crucial to make sure that the new building materials save labour on construction sites and contribute to even further project construction cost savings. Environmentally friendly and sustainable materials should be used in modern construction. The lack of availability and local manufacture of new materials is one of the primary factors influencing acceptance of new building materials. The novel materials ought to be adaptable enough to be further modified to meet the needs of the moment. Using waste goods will reduce the expense and amount of space needed for their disposal. While excessive plastic use should be discouraged, novel materials should have a positive environmental impact. In the early days of our ancestors, the shelters they erected were crude and only lasted a few months. Biomaterials such leaves, branches, bamboo, and twigs were used to build human shelters as well as cattle and crop product storage. Construction materials have evolved over time to include stronger elements like stone, wood, clay, and pebbles. A few years ago, there was a push to find more resilient, sustainable, and long-lasting materials that led to the advancement of manufactured materials like metal, cement, and block. The goal of this study was to examine the many kinds of cutting-edge building materials that are now on the market.

LITERATURE REVIEW

Capabilities are explored in terms of delivery and feedback mechanisms linking one firm’ s technical capabilities with those of other enterprises, with whom the firm collaborates, in order to produce one-off projects. A resource-based approach to the firm is taken, following Penrose’ s earlier work. Penrose, 1995 . The management of innovation is analysed in the context of the organisation of firms’ technical capabilities associated with their business processes. This is linked to project processes where firms’ technical competencies are practiced in association with technical capabilities from other firms. We contend that these types of activities require particular skills and resources that differ from those found in more stable production networks in which standard mass-produced products and services are delivered. Recent studies of innovation have pointed to the use of new forms of organisation to cope with increasing complexity of production, communications and technology Hedlund, 1994; Miles et al.,.1997: Hughes, 1998; Rycroft and Kash, 1999 . These suggest that firms have become increasingly reliant upon projects to organise the production of complex products and systems. There are coherent bodies of knowledge about innovation in projects, project management and the management of projects within. firms DeFillipi and Arthur, 1998; Morris, 1994 and an emerging literature on the virtual enterprise Nagel .and Dove, 1991 . We argue that project-based, service-enhanced forms of enterprise are not adequately addressed in the innovation literature. In this paper, we explore the way that these firms manage innovation in construction projects. Our aim is to develop a framework for understanding the dynamics of project-based firms, offering an approach to explaining how they might grow, improve performance and develop reputation for technical excellence. Our focus is on the relationship between firms’ core technical capabilities and the projects in which they work. Key issues for makers of complex products and systems in the built environment are not solely the management of projects or the management of business processes per se, but rather the integration of project and business processes within the firm. The rise in project-based organisational forms in other industries indicates that the problems faced by construction firms in their management of technologies may not be exceptional. The relentless project- based nature of construction serves to heighten the problems faced by firms in this sector. We suggest that our findings could also have implications for producers of a wide range of other types of complex products and systems. As Galbraith suggested in 1977, there is a continuum of organisational forms ranging from M-form through the matrix to the .project-based Galbraith, 1977 . Companies struggle to find the right balance between these various structures. However, there is an increasing trend in many industries toward a project-based approach to organi-Ž .sational design Miles et al., 1997; Hughes, 1998. For example, although the automotive sector has been used as the model of the M-form, there is evidence of increasing use of projects, especially in Ž .product development Womack et al., 1991. These issues have important consequences for general economic growth. In most OECD countries, the production and renewal of buildings and structures contributes around 7% of the total value of Ž .goods and services gross domestic product, GDP : the figure is higher if the value of construction-related materials and components is included. In some fast growing, newly industrialising regions, for example, until recently, in Japan and Korea, construction accounted for around 12% to 14% of GDP. These are large industries, often employing millions of people, accounting for around 8% or 9% of Ž .economy-wide employment in 1994 OECD, 1997. The role and significance of project-based firms in the production of the built environment extends far beyond their direct economic contribution to wealth creation. The products and services provided create and maintain the physical environment that supports existing and emerging social and economic activities. The provision of a high-quality built environment helps to facilitate wealth creation and improve living standards. If inadequate or inappropriate buildings are produced, or they are poorly maintained and adapted, then social and economic life is compromised. The ability to meet new demands and improve performance through the management of innovation is closely related to the development of technical capabilities within project-based design, engineering and construction firms. These firms operate within a dynamic environment in which rapid changes in the economy and society are creating demands for new types of buildings and structures. Processes of production, distribution and consumption are changing such that new facilities are needed for extraction of raw materials, processing, manufacture, retail and service sector activities. New infrastructures are required for transmitting information, transporting people, goods and services and providing basic utilities such as water, sanitation and power. Demand for new types of buildings to support information intensive activities and businesses in the emergent bio-technology and life-science industries poses particular technological and organisational .challenges for construction Gann, 2000.

S. No	Author Name	Year	Result
1	Penrose	1995	A resource-based approach to the firm is taken, following Penrose' s earlier work.
2	Hedlund	1994	Recent studies of innovation have pointed to the use of new forms of organisation to cope with increasing complexity of production, communications and technology
3	Miles et al	1997	Recent studies of innovation have pointed to the use of new forms of organisation to cope with increasing complexity of production, communications and technology
4	Hughes	1998	Recent studies of innovation have pointed to the use of new forms of organisation to cope

			with increasing complexity of production, communications and technology
5	Rycroft and Kash	1999	Recent studies of innovation have pointed to the use of new forms of organisation to cope with increasing complexity of production, communications and technology
6	DeFillipi and Arthur	1998	These suggest that firms have become increasingly reliant upon projects to organise the production of complex products and systems.
7	Morris	1994	There are coherent bodies of knowledge about innovation in projects, project management and the management of projects within. firms
8	Galbraith	1977	there is a continuum of organisational forms ranging from M-form through the matrix to the .project-based
9	Womack et al	1991	For example, although the automotive sector has been used as the model of the M-form, there is evidence of increasing use of projects, especially in product development
10	Gann	2000	Demand for new types of buildings to support information intensive activities and businesses in the emergent bio-technology and life-science industries poses particular technological and organisational .challenges for construction

USE OF MINERAL ADMIXTURE

Concrete composition has changed as a result of recent developments that have demonstrated the value of long-lasting concrete constructions. Cement, aggregate sand and water were the three or four ingredients used to make concrete until recently, but durable concretes today contain six or more building components. Mineral admixture has been the subject of numerous studies. The service life of concrete structures can be economically increased by mixing concrete with mineral admixtures in the batching plant or bond plant, which minimises microcracks in the concrete. Studies on mineral mixtures include the following.

(i) Fly Ash- When coal is burned in a power plant, an undesired fine solid residue byproduct results. Large amounts of these are manufactured. Power plant resources may incur expenses associated with the disposal of unused fly ash. Fly ash production currently stands at roughly 120 million tonnes per year, and not all of it can be utilised directly out of the ground. SiO 2, Fe 2 O3, Al 2 O3, and CaO are among the many components that fly ash may have. As a filler admixture in concrete, fly ash has been shown to reduce void content and can take on a variety of shapes, including amorphous ones. It is possible to apply 35 percent of the European Concrete Code.

(ii) Ground Granulated Blast-Furnace Slag (GGBS)- Slag, a liquid cooling waste product generated in the blast furnace during the smelting of iron ore, is the source of GGBS, a concrete admixture. When it comes to building development, the mineral additive in concrete is affordable, dependable, and sustainable. In order to produce concrete structures with a longer lifespan and better durability, GGBS is utilised in many nations, including the United States, Japan, Singapore, and Europe. Notable examples of these applications include the Burj Khalifa. The used GGBS improves the workability of concrete, lowers the risk of cracking from low early age temperature rises, reduces corrosion of reinforcement due to its strong resistance to chloride intrusion, has long-term advantages, is resistant to sulphate attack, and can also be used for precast concrete and in-situ stabilisation of soil.

(iii) Concentrated Silica Fume (CSF) as Admixture- In order to reduce the amount of water needed and increase the durability of a closely compacted concrete, the (CSF) that is obtained from Ferro-Silicon Industries has a small particle size that is significantly smaller than that of cement. By substituting 5– 10% of the cement with CSF, durable concrete can be produced. Only without commensurate technical benefits does the use of CSF for lower grades result in an increase in project costs. Examining condensed silica fume as an additive involves.

RESEARCH METHODOLOGY

(i) Organisation of the firm- The purpose of the research methodology was to investigate specific aspects of the organisational structures of project-based businesses. Studies on innovation have a propensity to see the firm as a single, measurable entity. For instance, Chandler's research shows that companies are logical structures built on divisions, with strong leadership originating from a core strategy team. Chandler (1990). Penrose's work also depicts the firm as a bounded entity, with distinct operationally recognisable divisions or units and coherent borders separating the firm's control and operation domain from its interfaces with outside activities. Penrose (1995).

(ii) Project and business levels of analysis- Businesses building sophisticated goods and systems must oversee both project and business processes due to the organization's split into project and business units. Project processes typically tend to be transient and one-of-a-kind, while business processes are typically ongoing and repeated. Brusoni et al., 1998; Gann, 1998. Businesses typically create routines as part of their operations. The regularity and repetition of their commercial operations allow them to maintain these routines. Regulars can foster creativity by offering chances for process standardisation and long-term enhancements. Project processes, on the other hand, typically include non-routine elements that are difficult to automate.

(iii) Studying project and business processes- The research process began with participating firms nominating initiatives for study. The projects were chosen because they are excellent illustrations of the company's current procedures. Project-based employees were interviewed in-depth to learn about their present work practices and interactions with core business functions. There were six interviews conducted for every project. The nature of the project and the technical assistance needed to meet its objectives were questions posed to project actors. It was requested of project-based actors to evaluate the amount and calibre of assistance they obtained from central technical support groups.

(iv) Integrating the results- Each firm was evaluated based on its capacity to oversee projects and the business procedures involved in delivering a portfolio of projects, integrating the two viewpoints on firm practices. The management of project-related business processes is a generic business process in the construction industry, as Winch has indicated. Winch, 1998. For businesses in the industry that depend on their capacity to manage a portfolio of projects in addition to their project management skills, or the ability to oversee a single project, it offers a significant source of competitive advantage. Through interactive workshops, the research method was used to gather information about the practices of the participating firms, and the findings were shared with them.

PRODUCTION OF BRICKS

There has been a major technological breakthrough in the production of durable, reliable and high strength bricks.

(i) Use of Cigarette Butts in Production of Bricks- According to Dziadosz & Kończak stated that Innovation in construction materials produces a lighter, effective and efficient bricks from a cigarette butt. figure 1 shows a brick produced from cigarette butt.

Figure 1- Cigarette Butt Bricks

(ii) Pollution absorbing bricks- Pollution absorbing bricks thermal insulation, was incorporated as a standard ventilation system of the building. It consists of external bricks façade system and indoor insulation. The filtration system in the brick divides the matter particles suspended into the removable hopper at the base wall. The brick offers better air quality and also helps to reduce airborne breathing problems. figure 2 shows a plate describing pollution absorbing bricks.

(iii) Three Dimensional Printing (3DP) in Civil Engineering- One method of connecting or solidifying elements to form a three-dimensional item using a combination of materials (such as liquid molecules or powdered grains) under computer control is 3D printing. Rapid prototyping and additive manufacturing are two applications for 3D printing. With 3D model data, objects with nearly any geometry or form can be created. In a construction site, the printer creates in-situ earthenware blocks with an auxiliary capacity design. It will just take 15 to 20 minutes to create these bricks in bulk. Stacked hardened bricks can be used to create pillars, vaults, or walls. Studies on the use of 3D in civil engineering construction have been conducted.

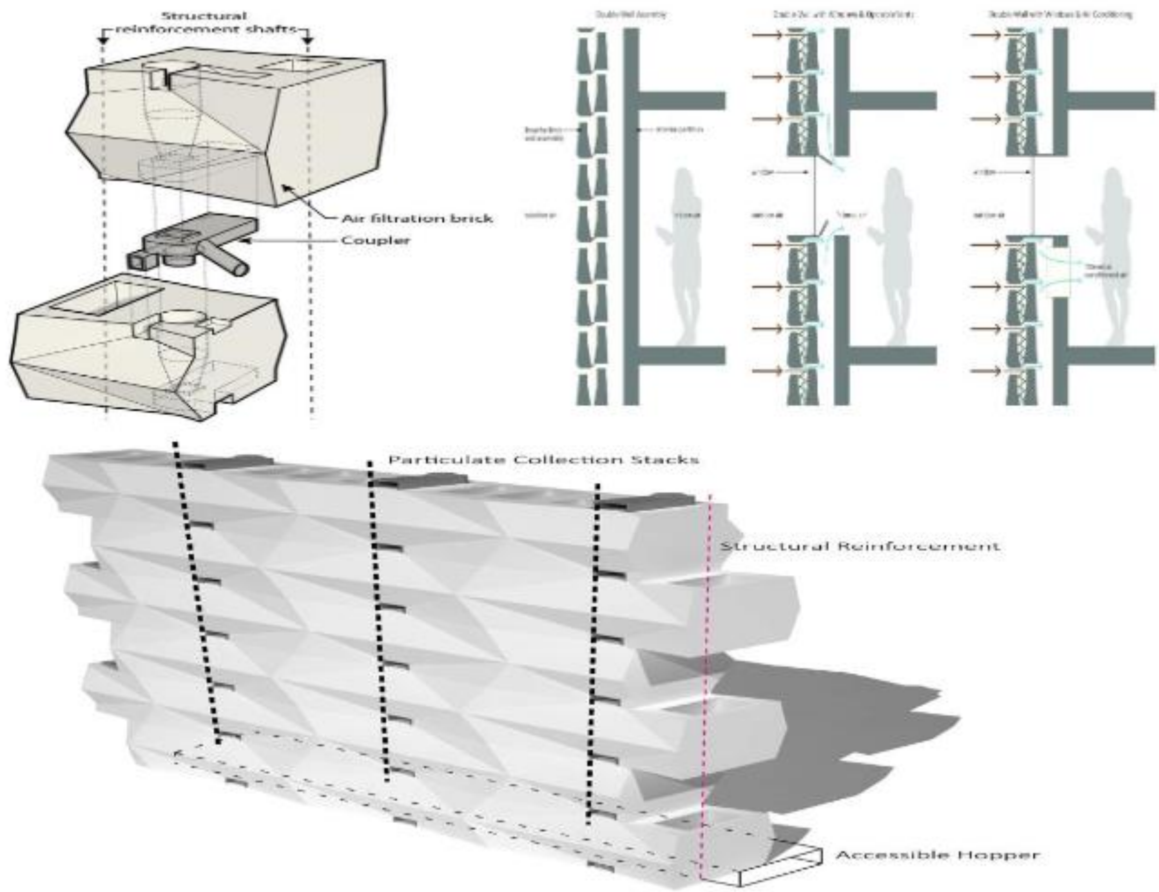

Figure 2- Pollution absorbing bricks

INNOVATION IN DESIGN, ENGINEERING AND CONSTRUCTION FIRMS

The particular characteristics of markets, industrial organisation, governance structures, technologies and competencies in design, engineering and construction provide the context for our analysis of forms of organising innovation in project-based firms. Figure 3 illustrates the types of actors, activities and knowledge flows found in construction activities. This model has six main analytical dimensions:

- Project-based firms.
- Project supply networks.
- Projects clients, owners, users .
- Technology support infrastructure.
- Regulatory and institutional frameworks.
- Knowledge flows.

In project-based productive networks, linkages between firms and other institutions differ from those found in traditional manufacturing approaches, which focus on individual firms with clear boundaries and transactions between them and their operations, working in a purely buy– sell relationship with one another. For example, attention may be focused on coordination mechanisms between firms, including non-market mechanisms such as indirect ownership, coengineering practices and partnering arrangements. We view construction as a process rather than an industry. In our definition, it includes designing, maintaining and adapting the built environment, involving many organisations from a range of industrial sectors, temporarily working together on project-specific tasks. Functions involve planning and design, engineering, supply and integration, erection and installation of a diverse array of materials, components and increasingly complex technical systems. The project-based nature of work implies that firms have to manage networks with complex interfaces. Delivery of products and services requires collaboration between firms. Performance and competitiveness depends not solely on the single firm, but on the efficient functioning of the entire network.

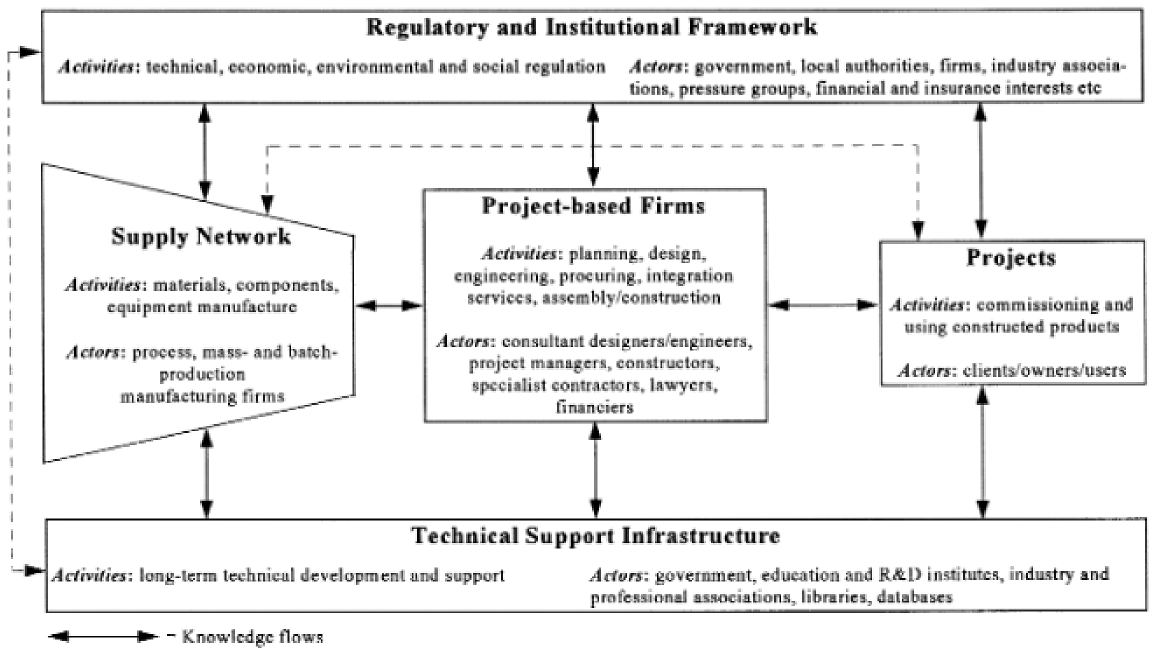

Figure 3- Knowledge, information flows and actors in project-based processes

CONCLUSION

The current standards for concrete construction are strength, durability, dependability, affordability, and environmental and human safety. Using the proper binders and admixture in the batching plant helps minimise microcracks in concrete and improve its structure more effectively. In construction projects, the cost of materials could account for as much as 40% of the total project cost. A few examples of cutting-edge building materials are 3D printing, 3D printed ceramics, laminated wood, aluminium foam, bamboo reinforced concrete, bio-receptive concrete, bricks created from pollutants, plaited microbial cellulose, super plasticizers and pollution-absorbing concrete. One of the developments in the field of building materials is the creation of Super Ductile Rebars, which are utilised in earthquake situations. There were documented success stories in the field of converting wastes into riches. In construction projects, the cost of the materials used could account for up to 40% of the total project cost. It is crucial to prioritise meeting certain criteria before implementing innovative construction materials. These include but are not limited to sustainability, durability, dependability, safety, economy, improved quality, enhanced mechanical and physical characteristics, flexibility in harsh environments, ease of assembly, and environmental friendliness. This study offers the most recent data on a number of cutting-edge building materials that are now on the market to the construction industry. This will provide even more value to the building material database.

REFERENCES

[1] Kanellopoulos A, Nicoladies D, Petrou M F, 2014 Mechanical and durability properties of concretes containing recycled lime powder and recycled aggregates Constr. Build. Mater. 53 253259

[2] CZarnecki L and Van Gemert D 2017 Innovation in construction materials engineering versus sustainable development. Bullet. Polis. Acad. Sci. Tech. Sci. 6 768771

[3] Andrade J J, Possan E, Squiavon J Z and Ortolan T L 2018 Evaluation of mechanical properties and carbonation of mortars produced with construction and demolition waste Constr. Build. Mater. 1617083

[4] Khitab A, Anwar W, Mansouri A, Kashan W, Tariq M K and Mahmood I 2015 Future of civil engineering materials: a review from recent developments Adv. Mater. Sci. 4 2027

[5] Oled K 2018 Innovative solution in construction industry. Review of 2016-2018 Events and Trends 10027033

[6] More T G and Autade P B 2015 A study on concrete properties by partial replacement of sand by pond ash Int. Res. J. Eng. Tech. (IRJET) 2 244254

[7] Honrubia M (2017, November 8) Four innovative construction materials that come from the future.

[8] Khandve P 2014 Nanotechnology for building material Inter. J. Basic Appl. Res. 4, 146151

[9] Mu L and Sprando R L 2010 Application of nanotechnology in cosmetics. Pharma. Res. 27 17461749

[10] You J, Mills-Beale J M, Folev S, Roy G M, Odegard O, Dai and Goh S W 2011 Nanoclay-modified asphalt materials: Preparation characteristics. Const. Build. Mater. 25 10721080

[11] Konsta-Gdoutos M S, Metaxa Z S and Shah S P 2010 Multi-scale mechanical and fracture Characteristics and early-age strain capacity of high performance carbon/nanotube/cement nanocomposites. Cem. Conc. Comp. 32 110115

[12] Kapliński O, Košeleva N and Ropaitė G 2016 Big data in civil engineering: A state-of-the-Art survey. Eng. Struct. Tech. 8 165175.

[13] Kapliński O, Werner W, Kosecki A, Biernacki J and Kuczmarski F 2002 Current State and perspectives of research on construction management and mechanization in Poland J. Civil Eng. Managt. 8221230

[14] Passuello A, Moriconi G and Shah S P 2009 Cracking behavior of concrete with shrinkage reducing admixtures and PVA fibers Cem. Conc. Comp. 31 699704

[15] Subalakshmi P, Saraswathy V and Sivasankaran S K 2012 Hydraulicity of mineral admixtures in cement blends Constr. Build. Mater. 36 648653

[16] Altwair N M and Kabir S 2010 Green concrete structures by replacing cement with pozzolanic materials to reduce greenhouse gas emissions for sustainable environment Proc. 6th Int. Eng. Constr. Conf. (IECC'6) (Cairo: Egypt) p 269279

[17] Gajzler M 2016 Usefulness of mining methods in knowledge source analysis in the construction industry Arch. Civil Eng. 62 127142

[18] Dziadosz A and Kończak A 2016 Review of selected methods of supporting decision-making process in the construction industry Arch. Civil Eng. 62 111126
[19] Zhuang X Y et al 2016 Fly ash-based geopolymer: Clean production, properties and applications. J. Clean. Prod. 125 253267
[20] Dziadosz A and Kończak A 2016 Review of selected methods of supporting decision-making process in the construction industry Arch. Civil Eng. 62 111126
[21] Zima K and Leśniak A 2013 Limitations of cost estimation using building information modeling in Poland J. Civil Eng. Arch. 7 545554
[22] Reddi S 2009New construction materials for modern projects. Retrieved November 15, 2018, from nbmcw: