Application of Nanotechnology in Iraqi Construction Projects

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Abstract. The great potential of nanotechnology in the construction sector, through many applications, such as innovative building materials and intelligent building systems. The paper aims to determine the level of knowledge for Nanotechnology in Iraqi Construction Projects. These knowledge levels are essential to develop construction project management, then identification obstacles to application Nanotechnology in Iraqi projects. The closed questionnaire using items of question measured by five-point Likert scale, including structured questionnaires (n = 68), interviews (n = 12). Lacks the set of knowledge currently required to be qualified and effective in practice for use in the construction industry.

Keywords: Construction Nanotechnology, sustainability building, civil engineering.

1. Introduction

Project management problems take on particular importance in nanotechnology because of the innovative character of the projects to be implemented [1]. Understanding and controlling materials at the level of individual atoms and molecules in nanotechnology within the range of 1–100 nm (10⁻⁹ m) and the creation of materials, systems, and devices with unique properties and new functions [2]. Nanotechnology signifies the main opportunity for the construction industry to develop new products [3], high performance, Promote quality, energy efficiency, economic sustainability by balancing environmental requirements and reduce maintenance costs [4]. Nano modifications increase the strength of current or innovative materials when applied in the construction industry. Improved physical properties (strength and durability) [5], Reduced construction costs due to the cheapness of raw materials [6], More Sustainable Construction [7, 8].

1.1. Nanotechnology for concrete

The compressive strength for concrete increases via added nano-SiO₂ at an early age [9]. Enhanced pore volume distribution can occur by filling the pores between cement particles with nano-scale. Besides, can close tiny cracks on the concrete surface by Using fiber sheet containing nano-silica particles and hardeners permeate [10]. Adding a small amount of carbon nanotubes to the Portland cement developed the mechanical features. Moreover, increase the compressive and flexural strength to the reference samples deprived of the reinforcement [11,12]. Admixture fly ash (industrial waste products) with the cement led to reduce the requirement for cement and funding to sustainability, also improves concrete durability and strength [13].

1.2. Nanotechnology for steel

Copper nanoparticles added to steel reduce surface unevenness and increase safety thus avoiding fatigue cracking [14]. Weld toughness increased when added Nanoparticles of magnesium and calcium [15]. MMFX2 is produced by MFX Steel Corp, nanostructure modified steel, USA. MMFX2 steel has a lower...
cost than stainless steel and corrosion resistance similar. To date, the MMFX Steel has got a certificate for general construction use throughout the United States [16]. Steel cables are used in the construction of bridges and pre-cast of concrete, and stronger cable materials will reduce costs and construction time [5].

1.3. Nanotechnology for Coatings
Paint containing nanoparticles or nanolayers was developed for: an anti-corrosion or caring coatings for components; thermal control, self-cleaning, antibacterial coatings for work surfaces; anti-reflection coatings for glass/windows; and more durable paints and anti-graffiti coating for buildings such as concrete walls [13] and structures [10]. Epoxy nanocomposite coatings with SiO$_2$, Fe$_2$O$_3$, TiO$_2$, ZnO, and clay nanotubes were successfully produced on a steel substrate at a concentration of the total weight of epoxy resin [17].

1.4. Sensors Nanotechnology for
Micro electrical and Nanomechanical systems sensors(MEMS) have been advanced in production to observe and control the materials/structure performance and the environment condition [18]. Incorporated MEMS sensors can be consumed to observe a range of concrete properties, including temperature, humidity, humidity, chloride ions, water-related degradation, and carbon dioxide [13].

1.5. Nanotechnology for glass
TiO$_2$ coating captures and destroys organic and inorganic air pollutants and bacterial membranes through a photocatalyst process. Self-cleaning assets for Nano TiO$_2$ useful in windows. Also, NanoTiO$_2$ coverings can be applied to building exteriors to inhibit pollutants, and thus reduce a facility’s keep costs [15].

1.6. Nanotechnology for wood
Nanotubes or nanofibers in composite wood, make elements (wood tissue) twice as strong as steel. Harvesting these nanofibers will clue to a different paradigm in sustainable construction because production and use will be part of a renewable cycle [6].

1.7. Nanotechnology for Insulation
Efficient insulation methods and materials in buildings is an important aspect of sustainability through efficient use of energy. Buildings consume more energy produced, and households account for a quarter of carbon emissions, which come from meeting space heating needs [14]. Air gel which has a treble density of air but has great strength and insulation capabilities. Air gel, currently used in solar collectors, is solid, but so transparent that it looks like a hologram [19].

2. Methodology

2.1. Information and Sample
In this study the questionnaire consists of two main parts, the first part is the level of knowledge of nanotechnology in Iraqi construction industry (8 factor). Part two especially obstacles of implementation nanotechnology in Iraqi construction projects (13 factor). The five-dimensional Likert scale was used in the questionnaire, the rating from small scale (1) to high scale (5) including questionnaires (n = 68), interviews (n = 12). The target group are engineers who work in construction design, supervision, implementation, and maintenance engineers (architecture, civil engineers, mechanical engineers, chemical engineers) and any related engineering specialty.

2.2. Measurements
The first step measures the validity and reliability of the questionnaire by Cornbrash's Coefficient Alpha method and Half Split method. After that, finding the descriptive Statistics (The mean, Standard deviation) then finding Relative Important Index (RII), one sample t-taste. The second step includes the test of hypotheses by the inferential statistics test, ANOVA test (One-way Analysis of Variance) [20].
2.3. Statistical Tools
The Statistical Package for Social Sciences (SPSS version 23) is used in the analysis of data.

3. Results and Discussion

3.1. The validity and reliability of the questionnaire
As shown in Table 1, the result of validity and reliability for the questionnaire by Cornbrash's Coefficient-Alpha method and Half-Split technique [21]. The coefficient alpha ($C_\alpha$) and Guttman split-half Coefficient was calculated for two parts, the result ensures the reliability of the questionnaire, because the reliability outcomes are higher than 0.6.

| Part                                      | Cronbach's Coefficient Alpha | Guttman split-half Coefficient | Number of factors |
|-------------------------------------------|------------------------------|-------------------------------|-------------------|
| The level of knowledge of nanotechnology | 0.806                        | 0.91                          | 8                 |
| Obstacles to the application of nanotechnology | 0.853                        | 0.873                         | 13                |

3.2. The Descriptive Statistics
The knowledge level of nanotechnology containing eight questions to evaluate the level of knowledge by specialists in Iraq. And obstacles to the implementation of nanotechnology covering 13 questions. The five-dimensional Likert scale was used in the questionnaire, the rating from small scale (1) to high scale (5) including -questionnaires (n = 68). This data was presented to the participants' views. As shown in Table 2 the descriptive statistics of the questionnaire results.

3.3. Relative Importance Index (RII) of nanotechnology in Iraq
Offered to the participants and take their views about these factors then analyzed. The analysis by SPSS 23, includes a one-sample t-test (2-tail), P-value, Relative Importance Index RII, and rank factors that are offered in Table 3. Citing of values that ranking based on the highest RII, mean and the lowest SD, if some items have similar RII, Means, as in the case of (B6, B1), (B8, B2), and (B12, B3).

It was important to determine the neutral value of RII and compares the total RII with the neutral value of RII. Consequently, the neutral value for RII is (3/5)x100 = 60%. Based on all of that, and as shown, the level of knowledge for nanotechnology in Iraq as Low level. Regarding results for all items of the part of Nanotechnology obstacles, they show that the Mean for all those items equals 4.11 and the total RII equals 82%, which is greater than 60% Also, the value of t (tabulated t), at a degree of freedom 67 and significance level = 0.05, equals 1.996, as shown the value of t-test greater than the value of t (1.996), P-value of all items a smaller than the significance level 0.05.

3.4. Hypothesis related to respondents' profiles
By taking into account the percentage knowledge of nanotechnology, One-way Analysis of Variance (ANOVA) provides a parametric statistical test of whether the Means of several groups (more than two) are equal or not (by using the F-ratio). As shown in table 4.

The critical value of F at degree of freedom = [(K-1), (N-K)] at the significance (probability) level (α) = 0.05, df = [(4-1), (68-4)] = [3, 64] and critical value of F at significance (Probability) equals 2.75. We used one-way ANOVA to test the differences among the opinions of the respondents taking into account the Percentage knowledge of nanotechnology. Regarding F-test, the significance values for A-part P-value < 0.05. Also, the values of the F-test for A-part are greater than the critical value of F 2.75.
Table 2: Statistical information for the questionnaire

| No. | Factor                                                                 | Mean  | Sta. Dev. |
|-----|------------------------------------------------------------------------|-------|-----------|
|     | **The level of knowledge of nanotechnology**                           |       |           |
| A1  | I have read some research and studies about nanotechnology.            | 2.15  | 0.919     |
| A2  | Some of my college courses at University talked about nanotechnology.  | 1.68  | 0.969     |
| A3  | I have High-rate information about nanotechnology.                     | 2.16  | 0.940     |
| A4  | I have an idea on how nanotechnology is applied in the engineering    | 2.34  | 1.016     |
|     | construction industry.                                                 |       |           |
| A5  | I know that the application of nanotechnology in the engineering     | 2.72  | 0.844     |
|     | construction industry has a great impact.                              |       |           |
| A6  | I use nanotechnology in my engineering field.                         | 1.93  | 1.238     |
| A7  | I believe that nanotechnology is an important building industry and   | 3.51  | 0.970     |
|     | builds construction in Iraq.                                           |       |           |
| A8  | I think that Nanotechnology has a positive impact on the sustainable   | 3.88  | 0.873     |
|     | environment.                                                           |       |           |
|     | **Obstacles to the application of nanotechnology**                    |       |           |
| B1  | Lack of knowledge of nanotechnology and its importance in the engineering field by stakeholders. | 4.19  | 0.966     |
| B2  | Lack of knowledge of how nanotechnology is applied in the field of design and construction projects by engineers. | 4.15  | 0.868     |
| B3  | High costs for processing nano construction materials and equipment for examination. | 4.09  | 0.893     |
| B4  | There are no government systems that fully support the application of nanotechnology in Iraq. | 4.29  | 0.947     |
| B5  | Engineers prefer to work with traditional materials.                    | 3.74  | 1.217     |
| B6  | The absence of scientific training courses The engineers know the benefits and importance of nanotechnology in engineering projects. | 4.19  | 1.055     |
| B7  | The unwillingness of engineers to learn new techniques at work.        | 3.43  | 0.759     |
| B8  | The weak level of government financial funding directed to promote the purchase of nanomaterial. | 4.16  | 1.101     |
| B9  | The lack of interest of civil society members in scientific research within its research institutions. | 4.07  | 0.919     |
|     | Absence of the role of companies and the private sector in financing     |       |           |
|     | scientific research on nanotechnology and not to benefit from the research outputs of scientists. | 4.40  | 0.849     |
| B10 | There is no support for nanotechnology research and studies. The private sector from industrial and investment companies to establishing private laboratories or providing financial support to universities to carry out joint development research projects. There are two benefits for the company providing support, benefiting from research and training facilities for its employees within universities. Which becomes a community partnership. | 4.25  | 0.887     |
| B11 | The absence of a teamwork culture and cooperation between the engineering specialties of the research bodies. | 4.12  | 0.970     |
| B12 | Lack of a culture of public awareness and dissemination of nanotechnology in audio, visual, and visual ways. | 4.35  | 0.748     |
Table 3. Relative Importance Index (RII), t (2-tail), P-value, and rank factors.

| Factor | RII | t-value | P-value | Rank |
|--------|-----|---------|---------|------|
| The level of knowledge of nanotechnology | | | | |
| A1     | 0.43| 7.657   | 0.000   | 6    |
| A2     | 0.34| 11.266  | 0.000   | 8    |
| A3     | 0.43| 7.352   | 0.000   | 5    |
| A4     | 0.47| 5.369   | 0.000   | 4    |
| A5     | 0.54| 2.731   | 0.008   | 3    |
| A6     | 0.39| 7.153   | 0.000   | 7    |
| A7     | 0.70| 4.378   | 0.000   | 2    |
| A8     | 0.78| 8.335   | 0.000   | 1    |
| All A- item | 0.51| 5.337   | 0.000   | -    |
| Obstacles to the application of nanotechnology | | | | |
| B1     | 0.84| 10.169  | 0.000   | 5    |
| B2     | 0.83| 10.892  | 0.000   | 8    |
| B3     | 0.82| 10.045  | 0.000   | 10   |
| B4     | 0.86| 11.266  | 0.000   | 3    |
| B5     | 0.75| 4.982   | 0.000   | 12   |
| B6     | 0.84| 9.314   | 0.000   | 6    |
| B7     | 0.69| 4.631   | 0.000   | 13   |
| B8     | 0.83| 8.701   | 0.000   | 7    |
| B9     | 0.81| 9.629   | 0.000   | 11   |
| B10    | 0.88| 13.571  | 0.000   | 1    |
| B11    | 0.85| 11.617  | 0.000   | 4    |
| B12    | 0.82| 9.500   | 0.000   | 9    |
| B13    | 0.87| 14.907  | 0.000   | 2    |
| All B-items | 0.82| 16.086  | 0.000   | -    |

Table 4. ANOVA -test results regarding the current the Percentage knowledge of nanotechnology.

| Part | F-test (ANOVA) | P-value (Sig.) | Less than 25% N=32 | 25% to less than 50% N=25 | 50% to less than 75% N=9 | More than 75% N=2 |
|------|----------------|----------------|---------------------|---------------------------|--------------------------|-----------------|
| All A-item | 18.108 | 0.000 | 2.148 | 2.760 | 3.222 | 3.875 |
| All B-items | 0.408 | 0.748 | 4.108 | 4.166 | 4.042 | 3.731 |

4. Conclusions and Recommendations
Based on the results of the study, the level of awareness of nanotechnology is low by engineers in the Iraqi construction. Also, there is a statistically significant dissimilarity between academic professionals and engineers working in the fields of design, implementation, and supervision. And we found the obstacles of nanotechnology are substantially affecting the adoption of nanotechnology in Iraqi construction. Academic institutions and universities should play a key role in introducing engineers to nanotechnology concepts, functions, and benefits. This can be done by conducting various workshops and providing technical training courses in the application of nanotechnology in construction properly.
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