Interaction between Theory and Practice in Civil Engineering and Construction
Edited by Komurlu, R., Gurgun, A. P., Singh, A., and Yazdani, S.

ISBN: 978-0-9960437-2-4

BARRIERS TO NEW TECHNOLOGY DISSEMINATION IN THE CONSTRUCTION INDUSTRY

MASOUD ZAVARI, MOHAMMAD MEHDI MORTAHEB, and HAMED KASHANI

Dept of Civil Engineering, Sharif University of Technology, Tehran, Iran

Despite the common belief, there is a considerable amount of innovation that occurs in the construction industry. However, the construction industry has been relatively slow to embrace the full potential of many new technologies. Evidence suggests that there is a lag in the uptake and effective implementation of several new technologies such as mechanical rebar splicing system. The objective of this study is to identify the impediments or barriers to the implementation of innovative technologies such as mechanical rebar splicing systems in the construction industry. A comprehensive literature review is conducted to identify and classify the barriers to new technologies dissemination. The findings of this literature review are validated using interviews with the construction industry experts. This study contributes to the state of knowledge by identifying and classifying the barriers that generally hinder the dissemination of new technologies in the construction industry. The practitioners can utilize the findings of this study to design appropriate strategies to overcome the barriers for implementation of new construction technologies. As part of this study, the extent to which the identified barriers have hindered the adoption of rebar splices, a technology that has not been adapted to its full potential. A questionnaire was designed, which was categorized the identified barrier in five major categories of cost, society and regulation, knowledge, marketing, and technical matters. The findings of the survey it was concluded that the lack of knowledge has the highest level of impact.

Keywords: Innovation, Impediment, Coupler splices, Mechanical splices, Implementation, Technology adoption, Diffusion of innovation.

1 INTRODUCTION

Innovative products, means and methods, technologies, services and management strategies are essential to economic growth, sustained competitive advantage and the achievement of landmark projects (Schumpeter 1934). There is a common perception among some professionals that construction innovation is rare and that the industry is slow to change (Slaughter 1998). This perception sometimes stems from comparisons of the construction industry to other industries, in which the introduction and adoption of new technologies and products have been extensive over the past several decades. Despite this perception, innovation in construction does occur and has been documented by researchers (Slaughter 1998).

The present research aims identify the impediments or barriers to the implementation of innovative technologies such as mechanical rebar splicing systems in the construction industry. A literature review was conducted to identify and classify the barriers to new technologies dissemination. The findings of this literature review were validated using interviews with the construction industry professionals. The knowledge presented in this paper can be used by aspiring entrepreneurs and existing organizations in the construction industry to identify the barriers that hinder the adoption innovative technologies and design strategies that increase the likelihood of success of innovative method and technologies.

2 LITERATURE REVIEW

Several studies on how innovation could be implemented in construction projects have been undertaken (Slaughter 2000, 1999, 1998, 1993a, 1993b, Winch 1998, Tatum 1987). These studies usually focus on how innovation is managed within one firm. There are also a variety of barriers that can hinder the dissemination of innovation in a filed. Fundamentally for technology dissemination to take place a number of obstacles such as uncertainty surrounding the costs and benefits of adoption, asymmetric information on the value of the innovation, financial and skill requirements, externalities, and regulatory barriers must be overcome (Johnson and Lybecker 2009). Bowley (1966, 1960) found several barriers that hinder progress of innovation: form of contract, cost of carrying out research, lack of information on cost savings arising from the innovation and restrictions imposed by regulations. Gann (2000) identified other impediments to construction innovation: contractors and consultants are isolated from one another, contractors are often of small size and fragmented, there is absence of competitive pressures on non-innovative firms and contractors may be unable to specify their products. However, there is no academic research in construction industry to find and categorize all probable barriers. Finding different barriers by studying other fields' literature such as environment, agriculture and energy is helpful to determine effective factors for technology dissemination in construction industry (Johnson and Lybecker 2009, Mercado *et al.* 1998, Gan 1998).

3 RESEARCH METHODOLOGY

A hybrid research methodology is applied to identify a set of significant factors in dissemination of construction innovation. A preliminary list of factors from the literature is presented through semi-structured interviews with researchers and industry practitioners who were asked to provide their comments. A final list of variables is obtained from these interviews and is presented in Table 1.

A questionnaire is designed and distributed among construction professionals to determine the significance of each barrier in dissemination of mechanical splices' implementation. In-depth interviews were conducted to gather further information to supplement the data gathered from the questionnaires.

3.1 Identifying Barriers in Dissemination of Construction Technologies

Twenty five barriers in dissemination of construction technologies were identified through an intensive literature review using important databases. To ensure the adequacy and comprehensiveness of these variables, five construction professionals from Tehran were invited for a preliminary study that consists of semi-structured interviews. The five respondents were two structural designers, two contractors and one construction owner. The professionals that were selected had at least 20 years of experience in the construction industry in order to ensure valuable discussions on factor that hinder the adoption of innovation in construction. After removing two controversial factor, 23 preliminary factors were determined. The resulting factors are shown in Table 1.

Table 1. Barriers of construction technologies dissemination.

Cost effectiveness	Society	Regulations	Knowledge	Providers	Technical issues
Increase in labor cost	Lack of infrastructures	Challenge existing legal systems	Limited knowledge of clients	Inappropriate marketing	Existence of technical limitation
Limited added value	Incorrect governmental policy	No incentive regulations	Inappropriate teaching and prerequisite knowledge	Limited providers	Inappropriate supporting equipment
Uncertainty regarding to the qualities of innovation as well as future prices	Society informal regulations		Limited knowledge of designers	Inappropriate ongoing support and training	Lack of expert labor
Disadvantage on stakeholders' income			Limited knowledge of scientists	Unsuitable assistance with maintenance	
Increase in cost claims of stakeholders			Limited knowledge about providers		
Increase in cost of related matters to innovation					

3.2 Questionnaire Survey

The initially identified 23 factors vary in their significance for every innovation construction technology or method. Therefore, a questionnaire was designed based on the table 1 to determine the significance of each barrier for couplers' dissemination. In this study, the questionnaire is adopted as an appropriate quantitative data collection method. The main participants selected for the survey come from top companies. They were invited to rank the significance of each variable under five categories, namely, cost, society and regulation, knowledge, marketing and technical matters, on a five-point Likert scale, with 5 indicating the most significant and 1 indicating the least significant. Likert scales are widely used and considered suitable to measure the importance of factors (Wang *et al.* 2010).

The full survey was conducted in Tehran over a two-month period. A total of 50 copies of the questionnaire were distributed between construction professionals. The demography of the respondents is summarized in Table 2.

3.3 Data Processing

A mean importance rating was used to calculate the importance of each variable, Eq. (1):

$$u = \frac{n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{n_1 + n_2 + n_3 + n_4 + n_5} \quad (1)$$

where u is the mean importance rating of a variable, and n_1, n_2,n_3, n_4, and n_5 represent the number of respondents who rated the variable as 1, 2, 3, 4 and 5, respectively. A statistical test was also conducted on the mean importance rating of each factor to determine whether the respondents consider the variables significant or otherwise. The null hypothesis H_0: $u \le u_0$ was tested against the opposite hypothesis and H_1: $u > u_0$, where u_0 is the population mean. The decision rule was to reject H_0 when the calculated t value was larger than $t_{(n-1,\ a)}$, as shown in Eq. (2):

$$t = \frac{x - \mu_0}{S_x/\sqrt{n}} > t_{(n-1,\alpha)} \quad (2)$$

where the random variable $t_{(n-1,\ a)}$ follows a t-distribution with (n-1) degrees of freedom, x is the sample mean, S_x is the sample standard deviation, n is the sample size, which is 50 in this study, and u_0 is the critical rating garnered by the factor considered the most significant, which is fixed at 3.

Table 2. Demography of the respondents.

Educational background	**Percentages of respondents (%)**
B.S.	56
M.S.	38
Ph.D.	6
Age	**Percentages of respondents (%)**
20-33	66
34-47	25
48-61	9
Position	**Percentages of respondents (%)**
Structural designer	21
Construction contractors	26
Construction owners	16
Construction supervisors	23
Researchers	14

4 IN-DEPTH INTERVIEWS

After the barriers were identified through the questionnaire survey, in-depth interviews were conducted to help interpret and elaborate the collected data. A total of eight respondents expressed interest in participating in the in-depth interviews. Among the interviewees, three were structural designers, four were construction contractors and one was an owner. The interviews were conducted with an average duration of 25 min. These interviews mainly aimed to gather further elaboration and explanation to the critical barriers.

5 ANALYSIS

The mean importance ratings, standard ratings, and t values are calculated from the survey results. The factors are ranked according to the order of importance shown in Table 3.

Table 3. Survey results on mean importance ratings and hypothesis testing.

Variables	U	S	t value	Sig.	Rank
Cost					
Increase in cost	3.28	1.054	1.509*	.141	14
Limited added value	3.25	1.016	1.392*	.174	15
Price uncertainty	3.94	0.619	8.569*	.000	2
Cost of quality uncertainty	3.66	0.971	3.824*	.001	9
Increase in cost claim	3.22	1.039	1.191*	.243	16
Increase in cost of rebar contractors	2.78	1.039	-1.191	.243	20
Increase in cost of transportation	3.09	1.058	.501	.620	17
Society and regulation					
Informal society regulation	4.06	0.878	6.849*	.000	3
Challenge to legal system	2.84	1.019	-.867	.393	19
Lack of legal incentive	3.91	0.777	6.597*	.000	5
Knowledge					
Limited knowledge of structural designers	3.84	0.884	5.400*	.000	6
Inappropriate teaching and prerequisite knowledge	3.94	0.801	6.623*	.000	4
Lack of knowledge about performance	3.41	0.979	2.347*	.025	11
Limited knowledge of construction owners	4.19	0.644	10.424*	.000	1
Limited knowledge about providers	3.69	0.859	4.527*	.000	7
Marketing					
Inappropriate marketing	3.63	0.793	4.458*	.000	8
Limited providers	3.41	0.979	2.347*	.025	12
Inappropriate ongoing support, training and assistance with maintenance	3.31	0.859	2.058*	.048	13
Technical matters					
Oppose technical standards	2.69	0.738	-2.396	.023	22
Harder performance compared to other alternatives	2.97	1.332	-.133	.895	18
Inadequate expert labor	3.59	1.103	3.045*	.005	10
Inappropriate supporting equipment	2.56	0.914	-2.709	.011	23
Increase in conflict of construction teams	2.66	0.827	-2.350	.025	21

* t-value is larger than $t_{(49,0.95)}$, which is 1.6765.

According to survey results, fifteen barriers affect mechanical splices dissemination. As the conclusion of in-depth interview, all of the barriers were specified by this method and construction industry has to eliminate them if diffusion of mechanical splices is needed.

6 CONCLUSION

In its simplest form, innovation is positive change that results from the implementation of new ideas. There is a perception that innovation in the construction industry is lacking or occurs at a very slow pace. Innovations in the construction industry may take place at a lower rate compared to other industries, but it does, and must, occur in a competitive market. The literature suffers from the lack of research on critical factors that can be used to guide construction industries to transfer technologies. In this study, through an examination of the literature and through semi-structured interviews with various professionals, 23 barriers under five categories were identified. These factors can potentially affect new technologies dissemination in construction industry and they were ranked for mechanical splices according to their importance ratings based on a questionnaire survey. Fifteen factors with a t value above 1.6765 were perceived as the most significant in this field. These critical factors have been shown to be reasonable and reliable through a series of statistical analysis. The identified factors can be adopted to inform the development of effective dissemination strategies and reduce barriers.

Notably, this study is conducted in line with the particular context of Iran, especially Tehran. Nevertheless, the findings can serve as useful references for similar research attempts in other cities.

References

Bowley, M., *Innovation in Building Materials*, Gerald Duckworth, London, 1960.

Bowley, M., *The British Building Industry*, Cambridge University Press, Cambridge, 1966.

Gan, Lin., Wind energy development and dissemination in China, *CICERO Working Paper*, 1998.

Gann, D.M., *Building Innovation: Complex Constructs in a Changing World*, Thomas Telford, London, 2000.

Johnson, Daniel K.N., and Kristina M. Lybecker, Challenges to technology transfer: A literature review of the constraints on environmental technology dissemination, *Colorado College Working Paper*, 2009.

Mercado, Agustin, JR., Marco Stark, and Dennis P. Garrity, Enhancing sloping land management technology adoption and dissemination, *IBSRAM Proceedings*, 25-45, 1998.

Schumpeter, J., *The Theory of Economic Development*, Harvard University Press, Cambridge, MA, 1934.

Slaughter, E.S., Builders as sources of construction innovation, *Construction Engineering and Management*, 119(3), 532–549, 1993a.

Slaughter, E.S., Innovation and learning during implementation: a comparison of user and manufacturer innovations. *Research Policy*, 22, 81–95, 1993b.

Slaughter, E.S., Models of construction innovation, *Construction Engineering and Management*, 124(3), 226–31, 1998.

Slaughter, S., Assessment of construction processes and innovations through simulation, *Construction Management and Economics*, 17, 341–50, 1999.

Slaughter, E.S., Implementation of construction innovations, *Building Research and Information*, 28(1), 2–17, 2000.

Tatum, C.B., Process of innovation in construction firm, *Engineering and Management*, 113(4), 648–63, 1987.

Wang JY, Yuan HP, Kang XP, Lu WS., Critical success factors for on-site sorting of construction waste: a China study, *Resources, Conservation and Recycling*, 54:931–6, 2010.

Winch, G., Zephyrs of creative destruction: understanding the management of innovation in construction, *Building Research and Information*, 26(4), 268–79, 1998.