

## HOW TO PROMOTE OFF-SITE FABRICATION PRACTICE OF REBAR IN TURKEY?

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### ABSTRACT

The authors have previously explored the practices of Turkish contractors in a series of papers, using rebar as the focal point. The exploratory studies have revealed a very complex socio-technical-economic system in play, the upshot of which is that performance is far from lean. This paper looks at the problem as representative of those faced by the construction industries in developing countries. First the system elements and dynamics are described, using force field analysis as the organizing tool. Then proposals are made for moving the industry toward lean construction practices, including optimal use of off site fabrication.

### KEY WORDS

rebar, off-site fabrication, barriers, improvement suggestions, Turkish construction industry

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## INTRODUCTION

Waste has been considered to be a significant problem in construction. Lean construction aims to extend the objectives of minimizing waste and maximizing value advocated within lean production management into the development of specific tools and techniques for lean construction project delivery (Lean Construction Institute<sup>3</sup>). One potential means of minimizing waste and maximizing value in construction is eliminating, or at least drastically reducing, on-site activities via off-site production of the components used in construction process (also named prefabrication or pre-assembly) (Koskela, 1997; Crowley, 1998; Egan, 1998; Gibb, 1999; Vrijhoef and Koskela, 2005).

Off-site production promises several advantages including less project duration, higher quality, lower cost, more productivity, fewer people on site, and simpler work process (Gibb and Isack, 2003). The benefits of off-site production are largely dependent on project-specific conditions, and the combination of building methods used on a project. Decisions regarding the use of off-site production are still unclear, complex, and largely based on anecdotal evidence rather than rigorous data, as no formal measurement procedures or strategies are available (Blismas et al., 2006).

In Turkey, reinforced concrete structures are most commonly preferred rather than steel structures. Precast concrete systems may be a good example of off-site production that is in line with lean construction principles since it significantly reduces on-site activities and offers significant benefits such as high quality, short project duration, and low cost (Sacks et al., 2004); however, on-site production of reinforced concrete systems is most commonly preferred in Turkey rather than precast concrete systems. On site production of reinforced concrete systems requires a great number of components; however, rebar is very critical in this process. Any inefficiency in the rebar supply chain may result in substantial delays and significant cost overruns. Thus, rebar supply chains need to be well managed in order to enhance construction process (Polat and Ballard, 2003).

In the construction process of reinforced concrete structures, one potential way of streamlining rebar supply chains and ultimately maximizing efficiency is off-site fabrication of reinforcing steel bars (rebar) (Pheng and Hui, 1999; Formoso et al., 2002). The main advantages of off-site fabrication of cut and bent rebar include major reductions in investment costs, labor cost, waste, inventory cost, and cycle time (Pheng and Hui, 1999; Pheng and Chuan, 2001; Formoso et al., 2002; Polat and Ballard, 2005a). Although off-site fabrication of cut and bent rebar provides contractors with numerous advantages, there is still a strong preference for on-site fabrication of rebar in the Turkish construction industry (Polat and Ballard, 2003; Polat and Ballard, 2005a,b).

Polat and Ballard (2005a) identified the barriers to the deployment of off-site fabrication of rebar in Turkey and found that most Turkish contractors prefer on-site fabrication of cut and bent rebar because of four basic factors commonly encountered in Turkey as well as many other developing countries:

- *Technical problems:* Contractors are faced with delayed delivery times of off-site fabricated rebar resulting from a long procurement process and large lot

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<sup>3</sup> [www.leanconstruction.org](http://www.leanconstruction.org)

sizes imposed by rolling mills that usually operate on mass production rather than lean production, and contractors may consequently suffer scheduling problems.

- *Managerial problems:* Contractors lack the management capability to coordinate the rather involved procurement process from off-site fabricators because their ordering procedures suffer from many deficiencies.
- *Ethical problems:* Contractors try to avoid receiving substandard or defective rebar from off-site rebar fabricators who sometimes attempt to hide the low quality of the raw materials they use. On the other hand, contractors themselves are sometimes tempted to overcharge their clients by exaggerating the number on workers employed and/or the amount of scrap generated in on-site fabrication setups.
- *Economic problems:* The national economy is plagued by high inflation rates that make material prices quite volatile and wages quite unpredictable. Consequently, the timely and economical supply of cut and bent rebar obtained from off-site fabricators becomes unreliable and contractors are forced to set up their own on-site fabrication workshops in order to control future uncertainties better.

The major forces that are for or against the deployment of off-site fabrication of rebar in the Turkish construction industry are illustrated in Figure 1.

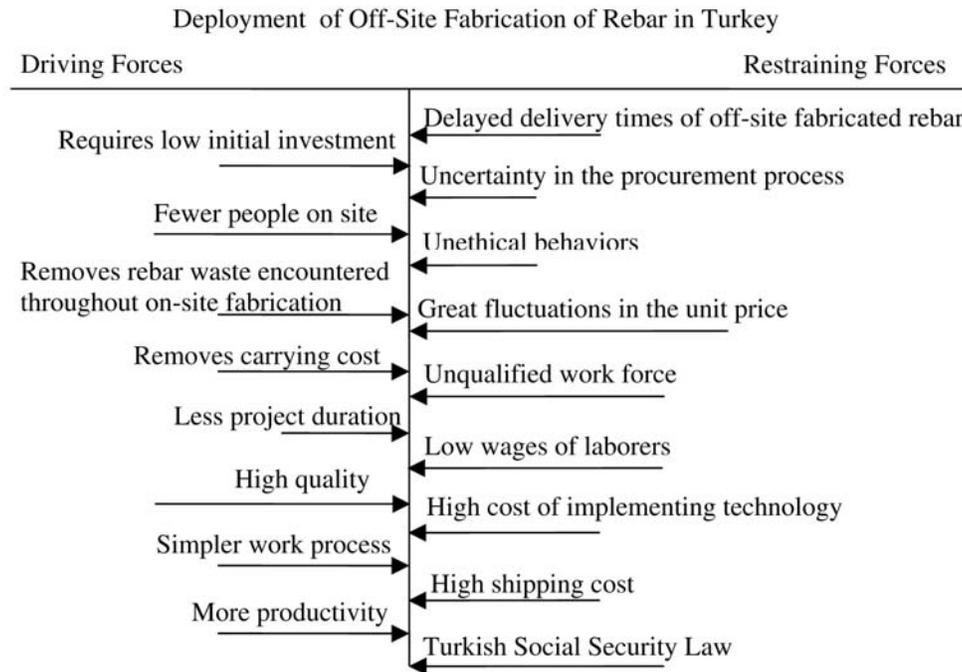


Figure 1: Forces for and against the Deployment of Off-Site Fabrication of Rebar in Turkey

While some of these restraining forces may likely be overcome through implementing various companywide improvements, overcoming the remainder forces requires nationwide and industry wide improvements. The purpose of this paper is to evaluate forces for and against the deployment of off-site fabrication of rebar in Turkey and to propose a strategy for promoting off-site fabrication practice of rebar via increasing positive forces and reducing negative forces, which are peculiar to the conditions prevailing in the Turkish construction industry, and perhaps the construction industries of other developing countries, that prevent Turkish contractors from preferring off-site fabrication of rebar.

### **BARRIERS TO THE DEPLOYMENT OFF-SITE FABRICATED REBAR IN TURKEY AND SOME IMPROVEMENT SUGGESTIONS**

Off-site fabrication of rebar potentially has several advantages. However, the use of off-site fabrication of rebar is very low compared with the use of on-site fabrication. Definitely, the foremost reason behind that preference is that most contractors believe that off-site fabrication of rebar is not as economical as on-site fabrication of rebar. In addition to that perception of Turkish contractors, the current state of the Turkish construction industry discourages adoption of off-site fabrication practices. The major factors that hinder the deployment of off-site fabrication practices in the Turkish construction industry and some recommendations for overcoming those problems are discussed below:

#### **NATIONWIDE OBSTACLES AND IMPROVEMENT SUGGESTIONS**

**Turkish Social Security Law:** In Turkey, the relationships between employers and their employees are governed by the Social Security Law (SSK). This law sets the rules for the minimum rate of the sum of wages that should be paid to the laborers in a project to the contract value of the project. According to this law, in a building project, a contractor should pay 9% of the contract value to the laborers working in that project. Otherwise, the contractor is not permitted to deliver the project to the owner. For instance, if the contract value of the project is \$4 million, then at least \$360,000, which corresponds to 486,000 YTL, should be paid to the laborers throughout the entire project. If this amount is not paid to the laborers, then the contractor is obligated to pay a penalty. Having assumed that the project is completed within a year, at least 34 laborers should continuously be employed in the course of that project. The main reasons behind that rule are to increase the employment in the Turkish construction industry by means of encouraging contractors to recruit laborers and to protect the rights of the laborers through avoiding contractors from recruiting laborers illegally and not paying their insurance premiums.

Apparently, since Turkey is a developing country and unemployment is one of the major problems, this law is very beneficial as it aims to encourage hiring laborers and to protect their rights; however, it is one of the significant barriers, which discourages contractors for off-site fabrication of rebar. The cost of fabricating rebar on site accounts for the significant proportion of the total cost of labor in the construction of the superstructure. On the other hand, when a contractor prefers off-site fabrication, the invoice of those off-site fabricated rebar will be considered to be a kind of material cost in the contractor's financial accounts. Thus, this law discourages contractors from implementing off-site fabrication practices and encourages on-site fabrication practices since it allows employing more laborers than off-site fabrication. In order to encourage contractors to prefer off-site fabrication practices, this law

should be modified to allow contractors to account the cost of cut and bent rebar as both material cost and labor cost in their financial reports.

**Great Fluctuations in the Unit Price:** In Turkey, inflation tends to increase over time, but the unit price of rebar is driven by market demand. The main reason behind this fact is that the major clients of the Turkish rebar industry are foreign construction markets rather than domestic construction market. Since the unit price of rebar in Turkey is governed by neither the domestic market demand nor the inflation rate, but by international market demand, Turkish rebar manufacturers or vendors sell rebar in foreign currencies such as US dollar or Euro rather than Turkish currency. Hence, the relative increase in cost of rebar purchased is commonly experienced. Then, claiming that the unit price of rebar usually increases over time would not be totally wrong. Undoubtedly, in a period of increasing price, buying rebar earlier would reduce the purchasing cost<sup>4</sup>, but in a period of decreasing price, buying rebar earlier would increase the purchasing cost. Moreover, when rebar suppliers have cash flow problems or when demand for rebar tends to decrease, rebar suppliers may be eager to sell the goods in their inventory immediately at greatly discounted prices. In such situations, contractors may prefer purchasing the low-priced rebar early and take advantage of the good deal. Generally, rebar suppliers make large discounts in case large amounts of rebar are ordered. This is particularly true in developing countries because rebar suppliers tend to protect themselves against demand fluctuations caused by an unstable economy and great gap between demands and supplies. In these circumstances, contractors have a tendency to purchase large quantities of materials in order to take advantage of the discounted prices. Thus, most contractors prefer on-site fabrication of rebar since it shields them from unpredictable increases and great fluctuations in the unit price of rebar by means of enabling purchasing rebar early and stockpiling. On the other hand, contractors should achieve JIT deliveries in off-site fabrication so that they can take advantage of that kind of practice.

Providing stable unit price of rebar or low fluctuations in unit prices of rebar by means of both balancing the amounts of demand and supply and shielding the unit price of rebar from high inflation may encourage contractors to fabricate rebar off site. However, no one seems to have much control over international commodity markets. Thus, suppliers should apply financial or insurance instruments in order to shield themselves from rapid, unpredictable and great fluctuations in unit prices of rebar.

#### **INDUSTRY WIDE OBSTACLES AND IMPROVEMENT SUGGESTIONS**

**Unqualified Work Force:** Polat and Ballard (2006) stated that it is very easy to become a construction worker in Turkey, because no certificate is required to prove your level of education or experience. A recent report also uncovered that work force is uneducated, unqualified, and unprofessional in the Turkish construction industry, and their skills are not satisfactory (DPT, 2004). In Turkey, Ministry of National Education (MEB) is responsible for elementary education (i.e., elementary schools, high schools, technical high schools) and Higher Education Association (YOK) is responsible for higher education (i.e., universities, colleges, academies,

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<sup>4</sup> Purchasing cost here represents the direct cost of rebar to the contractor and it is directly governed by the quantity of rebar to be purchased and the unit price of rebar when it is purchased. Carrying costs of inventory, such as the cost of capital tied up, storage costs, handling costs, etc., are separately calculated and incorporated in the model.

technical schools). Moreover, in Turkey, all kinds of training programs can only be initiated with the permission of MEB, namely an institution cannot conduct a training program and give a certificate to the attendants without the authorization of MEB. Since the potential means of improving laborers' qualifications is conducting training programs, MEB or other institutions held authorized by MEB should initiate training programs and give certificate to the successful attendants, which prove their level of education.

Apprenticeship programs, which are held in most European countries and the US, may be a good example of that kind of training programs. Apprenticeship is distinguished from other methods of training by the reciprocal rights and obligations it imposes on the provider and the receiver of training. The provider agrees to teach a broad range of skills required practicing an occupation and, in return, the apprentice agrees to work for the provider at a wage lower than that of a skilled worker. The system works on the premise that both sides would fulfill their obligations, which requires a formal or informal agreement. Apprenticeship programs may be sponsored either jointly by labor unions and contractors signatory to collective bargaining, or unilaterally by employers (Bilginsoy, 1998).

In addition to the absence of apprenticeship programs, MEB and YOK do not adequately encourage the establishment of technical schools, which should provide their students with practical knowledge as well as theoretical knowledge concerning their profession area. Although there are numerous civil engineering faculties that mainly provide their students with theoretical knowledge and graduate hundreds of civil engineers every year, there are few technical schools that mainly educate their students with practical knowledge and graduate qualified work force. This concern is also stated in DPT report (2004). According to DPT report (2004), both MEB and YOK should reconsider and restructure the Turkish education system in order to initiate new technical schools and promote those technical schools to graduate well qualified laborers endowed with both practical and theoretical knowledge.

Since training programs are not conducted and the number of technical schools is not sufficient, the qualifications of laborers are assessed only with respect to their years of experience in Turkey. In the current state of the Turkish construction industry, if contractors want to hire qualified laborers, then they should recruit experienced laborers or they should individually conduct training programs. Undoubtedly, that kind of individual initiatives is not adequate to increase the number of educated and qualified construction laborers.

In order to boost the qualifications of work force in construction, both the construction industry and government should do their parts. Training programs and technical schools should immediately be initiated with the help and support of government and relevant ministries and/or institutions. As a suggestion, MEB may authorize Ministry of Labor and Social Security (CSGB) to initiate training programs akin to apprenticeship programs on behalf of construction laborers.

**Low Wages of Laborers:** Mahirogullari (2001) reported that the low rate of unionization and high rate of unemployment are of the most significant reasons behind low wages of laborers in Turkey. Definitely, the level of laborers' wages is directly related to the qualifications of laborers, the overall state of the economy in the country, and as well as the extent of unionization in the country. While unionization is very low in Turkey compared with developed countries, the rate of unionized construction is even lower than other industries. According to Mahirogullari (2001) high rate of informal employment and unemployment, insufficiency of job security and privatization attempts deter the unionization efforts in Turkey.

Union shops do not exist in the Turkish construction industry, thus all of the construction laborers are from open shop. Given the fact that the laborers in the Turkish construction industry are unqualified, uneducated and their skills are not satisfactory, it is not surprising that their daily wages are very low compared with the daily wages of the construction laborers in developed countries. Low wages of the laborers is one of the significant factors that compel Turkish contractors to fabricate rebar on site. Even though employing incompetent laborers brings about huge amount of material and time wastes due to frequent reworks and huge amount of scraps, most Turkish contractors still hire inexperienced and uneducated laborers since their wage is very low.

Comparison of construction laborer wages in different countries is presented in Table 1. According to the data derived from Table 1, while the highest average weekly wage for the laborer is 1,252.63 YTL in Japan, the lowest wage is 168.72 YTL in Malaysia. A construction laborer earns 245.00 YTL per week in the Turkish construction industry. While a Japanese laborer earns 5.11 times more than a Turkish laborer, a Turkish laborer earns 1.45 times more than a Malaysian laborer.

Table 1: Comparison of Construction Laborer Wages (CIDB, 1994; JETRO, 2003)

| Country      | Average Weekly Wages in Local Currency | Average Weekly Wages in YTL <sup>5</sup> |
|--------------|--|--|
| Japan        | ¥113,875                               | 1,252.63 YTL                             |
| USA          | \$702.00                               | 955.47 YTL                               |
| UK           | £393.90                                | 939.85 YTL                               |
| Germany      | €531.90                                | 873.91 YTL                               |
| France       | €519.20                                | 853.05 YTL                               |
| Hong-Kong    | HKD4588.50                             | 734.16 YTL                               |
| Taiwan-China | CNY4218.00                             | 674.88 YTL                               |
| Singapore    | SGD354.00                              | 269.04 YTL                               |
| Turkey       | 245.00 YTL                             | 245.00 YTL                               |
| Malaysia     | MYR544.26                              | 168.72 YTL                               |

Based on the data given in Table 1, it can be inferred that average weekly wage of construction laborers in Turkey is lower than average weekly wage of construction laborers not only in developed countries but also in other developing countries. Establishment of labor unions and improving the laborers' qualifications would bring about higher wages of laborers, but also

<sup>5</sup> YTL=Yeni Turk Lirasi=New Turkish Lira (1 YTL = US\$0.74 = £0.42 = +0.61 = ¥90.91 = SGD1.32 = HKD6.25 = CNY6.25 = MYR 3.23) (obtained from [www.tcmb.gov.tr](http://www.tcmb.gov.tr), Central Bank of the Republic of Turkey, last visited on )

better project performance in terms of less laborers' mistakes, less material and time wastes, less reworks, and more importantly enhanced living standards for construction laborers. Of course, these results might also be achieved by other means; e.g., national legislation.

**High Cost of Implementing Technology:** In most developing countries, traditional methods are still used in construction. In the traditional construction process labor-intensive methods are used and large inventories of materials are kept. As a result, huge amounts of materials are wasted and quality problems are experienced. On the other hand, in developed countries, industrialized methods are exploited rather than traditional methods. In that kind of construction process, small or no inventories is kept and technology intensive methods (i.e., computer integrated construction, high level of machinery use, automation) are used. Thus, uninterrupted work flow is achieved, quality of the products is improved, and better project performance is attained.

Although industrialized construction methods promise several benefits to contractors, in most developing countries, the cost of implementing technology is high and the funds for R&D are insufficient (Oral et al., 2003) whereas the cost of laborers is very low but their skills are not satisfactory. Like many other developing countries, in Turkey, the cost of exploiting labor-intensive methods is much lower than that of implementing technology, i.e., off-site fabrication of rebar, precast concrete systems, and computer integrated construction.

According to Polat and Ballard (2006a,b), roughly 7%-11% of total rebar used in the trade center project they studied is wasted during on-site fabrication due to uneconomical shapes, laborers' mistakes and reworks. On the other hand, off-site fabrication of cut and bent rebar costs a contractor 10-12% more than purchasing straight rebar, yet the price for off-site fabrication of rebar includes the rebar fabricator's cost of laborer and scrap (wasted rebar) (Polat and Ballard, 2005a).

The former studies (Polat and Ballard, 2006a) revealed that the purchasing cost of straight rebar ranges between 180,890 YTL and 191,700 YTL, which also includes the cost of wasted rebar, and the cost of on-site fabrication, which includes the wages of laborers in charge of on-site fabrication of rebar, ranges between 3,900 YTL and 6,480 YTL. Briefly, the sum of purchasing cost and on-site fabrication cost ranges between 184,790 YTL and 198,180 YTL. On the other hand, Polat and Ballard (2006b) revealed that the cost of off-site fabrication ranges between 194,713 YTL and 199,686 YTL in the same trade center project. Obviously, implementing off-site fabrication practice of rebar in the studied project adds an extra cost ranging between 1,506 YTL to 9,923 YTL, which corresponds to a decrease of minimum 1% and maximum 5% in the profit margin of the contractor.

Obviously, in the current state of the Turkish construction industry, the cost of implementing technology is higher than practicing traditional construction methods, namely labor-intensive methods. The main reasons behind that fact are the lack of competence among the rebar fabricators due to the few number of rebar fabricators. Definitely, the cost of off-site fabrication should be lowered in order to encourage contractors to prefer that alternative. The cost of off-site fabrication can be lowered by means of; (1) amplifying the competence among the rebar fabricators by increasing the number of rebar fabricators, (2) boosting demand for off-site fabricated rebar in the construction industry, and (3) lowering the taxes in unit prices of off-site fabricated rebar. The number of rebar fabricators can be increased through endorsing entrepreneurs for making investments in off-site fabrication machineries and establishing new rebar fabricators. The demand for off-site fabricated rebar can be augmented by means of setting rules that determines the minimum percentage of off-site fabricated rebar quantity that

should be used in a project. The government and construction industry should do their parts in lowering the cost of off-site fabrication.

**High shipping Cost:** High shipping cost is one of the main reasons behind the strong preference for on-site fabrication of rebar in the Turkish construction industry. The former relevant studies seem to confirm that kind of consideration, because, while shipping cost accounts for ranging between 1.53% and 1.58% of the total cost of rebar in the on-site fabrication practice (Polat and Ballard, 2006a), it accounts for ranging between 2.30% and 2.46% of the total cost of rebar in the off-site fabrication practice (Polat and Ballard, 2006b). This finding seems very reasonable, because, in the off-site fabrication practice, the contractor achieves JIT deliveries in which the contractor orders exactly what is needed on site, a.k.a. lot-for-lot ordering. In that kind of ordering system, the number of deliveries and ultimately shipping cost increases. On the other hand, in the on-site fabrication practice, the contractor orders rebar in large lot sizes, namely more than needed, in order to take advantage of full capacity of trucks. That kind of ordering system lowers the shipping cost since rebar is moved from supplier's warehouse or fabricator's plant to the construction site in fewer deliveries. Definitely, lowering shipping costs may encourage contractors to fabricate rebar off-site.

Shipping cost is roughly calculated by multiplying the number of truckloads by the unit cost of delivery per truckload, thus, shipping cost can be lowered by achieving decrease in any or both of those factors. The number of truckloads is directly governed by the rebar management system (on-site practice; large lot size or off-site practice; small lot size) implemented by the contractor. However, the main point here is to lower the shipping cost regardless of the rebar management system implemented, so, the unit cost of delivery is the major factor that should be reduced in order to lower the shipping cost.

The unit cost of delivery is directly related to the transportation policies of a country. The potential means of commodity flow include transportation by highway, rail, air, and sea. In the usual case, highway and rail freight transportation means are most commonly preferred rather than other modes. Rail freight is much cheaper than highway freight, but its transit time is longer. If cost is more of a concern than time, that kind of transportation method may become a feasible option. Moreover, the capacity of railway freight and the length of the railway network are the major factors that promote the use of rail freight systems (Cinar, 2003). In most developed countries, rail freight transportation is widely preferred. For instance, 30.4% of freight traffic is conveyed by rail in the US and 13.4% of freight volume is carried by rail in the EU (Cinar, 2003). On the other hand, in most developing countries, including Turkey, highway freight transportation is commonly preferred. While the highway system carried about 89.1% of total freight traffic, rail systems moved about 4.76% of freight volume in Turkey (Cinar, 2003). The main reasons behind the strong preference for highway freight transportation are that the railway network is very short and the capacity of the rail system is not sufficient to move a high volume of freight traffic (Zeybek, 2003). In general, highway freight transportation is more costly than rail and sea modes, since more energy is consumed in the highway system and the unit cost of energy is more expensive. The unit cost of energy in Turkey is more costly than many other countries due to high taxes (Zeybek, 2003). The government should do its part in promoting rail and sea freight transportation by means of making investments in railway and seaway systems, and lowering the taxes in the unit cost of energy.

### COMPANYWIDE OBSTACLES AND IMPROVEMENT SUGGESTIONS

**Unethical Behaviors:** According to Polat and Ballard (2005a), one of the main reasons behind strong preference for on-site fabrication of rebar in Turkey is that it enables contractors to fiddle the numbers on workers and scrap in order to increase the money they receive from clients. By this way, contractors receive progress payments based on the inflated report and spend that extra money for the inevitable expenses that they cannot request from the owner including bribes that they pay to the municipality for permits, to policemen for security, and the control organization of the owner for allowing some of their minor mistakes. On the other hand, off-site fabrication prevents contractors receiving extra money from the owner as all cost drivers including labor and material are invoiced, thus, contractors prefer on-site fabrication of rebar so that they can compensate their inevitable expenses with the extra payments they receive from the client.

At first sight, it seems that those kinds of behaviors of contractors are unethical and should immediately be avoided. On the other hand, it should be kept in mind that the prevalent way of doing business in Turkey coerces contractors to do so. In the current state of the Turkish construction industry, contractors are somehow compelled to make those extra payments throughout the project and there is neither official nor legal way to request those payments from their clients, hence, contractors have to find a way to overcome this problem in order to keep up the project. Fiddling the numbers may neither be a honest nor ethical behavior, but it helps contractors in overcoming the problems resulting from the poor business system in Turkey. Strictly speaking, ethical problems are the consequences of ineffective laws, lacking business rules, deficient control mechanism, plus contractors' tendency to unfair incomes. Apparently, the current system should be reconsidered and restructured, for this purpose; both individual initiatives led by each project participant and a national initiative led by the government should be conducted. Improving construction industry performance is a matter of national importance and both deserves and requires government leadership in the formation of a government/university/ industry initiative. The Movement for Innovation in the UK (Egan, 1998) is one example of such an initiative.

### CONCLUSIONS

Rebar is critical in the construction process of reinforced concrete systems. One potential way of streamlining rebar supply chains and ultimately maximizing efficiency that is in line with lean construction principles is off-site fabrication of rebar. Although off-site fabrication of rebar provides contractors with numerous advantages, there is still a strong preference for on-site fabrication of rebar in the Turkish construction industry. There are three major factors that bring about strong preference for on-site fabrication of rebar, which are; technical, managerial, economical, and ethical problems. In a project environment in which those problems are commonly experienced, on-site fabrication of rebar results in less cost to the contractor compared with off-site fabrication of rebar, thus, it is very reasonable for a typical contractor to decide on on-site fabrication of rebar since the primary criterion is the economics of the rebar management selected. While some of those problems can be overcome through implementing various companywide improvements, overcoming the remainder problems requires nationwide and industry wide improvements.

In this study, driving and restraining forces for the deployment of off-site fabrication of rebar in Turkey are evaluated and a strategy for promoting off-site fabrication practice of

rebar is proposed. The driving forces for the deployment of off-site fabrication practices in the Turkish construction industry represent the potential advantages promised by off-site fabrication of rebar, which include major reductions in initial investment costs, laborer costs, waste encountered throughout on-site fabrication practice, carrying costs, project duration, and substantial enhancements in productivity, quality, and work process. On the other hand, the restraining forces represent the barriers to the deployment of off-site fabrication practices in the Turkish construction industry, which include nationwide obstacles (Turkish Social Security Law, great fluctuations in the unit price), industry wide obstacles (unqualified work force, high cost of implementing technology, high shipping cost), and companywide obstacles (unethical behaviors).

This study is useful in two ways. First, it identifies the driving and restraining, which are peculiar to the conditions prevailing in the Turkish construction industry, and perhaps the construction industries of other developing countries, that prevent Turkish contractors from preferring off-site fabrication of rebar. Second, it proposes a strategy for promoting off-site fabrication practice of rebar. Definitely, Turkish construction industry participants cannot enjoy the benefits of off-site fabrication practices unless those problems are overcome, hence, the government, other relevant institutions and contractors should do their parts in order to remove the barriers to the deployment of off-site fabrication practices.

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