

## **Treatment of Reinforcing Steel Bars Prices Fluctuations**

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**Abstract.** Recently, the price of steel bars used in reinforced concrete construction have almost doubled within a year in Saudi Arabia and elsewhere to various degrees. As a lead item of construction material, the sudden rise of steel rebar price has led to a fluctuation of other construction items prices such as cables, concrete, plasters and others.

This rise in steel rebar prices is attributed to numerous economic factors among them: the rise of raw materials, increased global demand, increase of shipping and insurance costs. By and large, there is no consideration of the treatment of escalation of the construction costs quantitatively and contractually in the Arabian Gulf countries since their economies are heavily dependant on the oil price while experiencing a little and stable overall macro inflation. However, alarmingly the recent escalation of the steel bars has created several contractual disputes, claims and breach of contracts. This paper tracks the pattern of the steel bars prices for the last two years in Saudi Arabia and provides a mathematical model for predicting its future prices. Owners, design firms and contractors can use the developed tool to 1) predict future prices of steel rebar, and 2) to enforce contract provision related to compensating the contractor.

### **Introduction**

Arabian Gulf countries, and particularly Saudi Arabia, had enjoyed a decade of sustained economical growth and boom right after the 1973 world oil crisis whereas Gulf States economies rely solely on the oil export. Back then, the prices went up four times virtually on most of the basic commodities and real estate prices skyrocketed tens of times of its past prices. Virtually, this was the first time that people had experienced high inflation associated with a heated economical growth in recent history.

Thereafter, annual inflation levels were almost very low, 2% to 3% [1] and stable for many reasons as oil price and production increase steadily while a semi lassie-faire labor policy allowed the import of expatriate and cheap labor from Asian countries which constitute almost 67% of the labor force in Saudi Arabia [2].

The construction sector in Saudi Arabia has experienced unprecedented growth right after the 1973 oil crisis of the last century as its share peaked at 50% of the Gross National Product in the late seventies; thereafter, it dwindled to 4% in 1999 and rose again to 11% in 2002 [3]. The construction sector is mainly influenced by government expenditures. Public contracts are regulated, by its Public Procurement Law and administered by Public Work Contracts. [4, 5]. It is also observed by the author that the industry lacks a reliable statistical backbone such as the database of unit costs of construction, list of building material index, inflation indicator, labor productivity and prices, equipment prices, equitable adjustment of contract sums, research and development among others in comparison with other sectors such as the financial sector. Modest and scattered efforts to establish construction unit prices include cataloguing construction materials prices on annual basis by the Chamber of Commerce [6], database of the construction center at the Ministry of Municipalities and Rural Affairs, construction cost database maintained by the Cost Estimate Center by the Ministry of Finance, database maintained by the Department of Works at the Ministry of Defense and protected database of construction costs maintained by Architectural and Engineering Firms and contractors. Consequently, disparate and confidential sketchy databases of construction estimates are generated to suit each party, under different assumptions and practices.

The treatment of construction cost inflation, in engineering contracts in Saudi Arabia, has been negligible for the last three decades due to the stability of construction materials prices and higher efficiency and productivity. However, the situation changed when recently the RB steel and other construction materials prices suddenly spiked during the period between the second half of the year 2003 and the first half of the year 2004. Subsequently, this has led to many disputes and claims between the various construction parties due to: lack of a recognized source or price database for the history of construction materials prices which periodically produces cost indexes to establish and measure the price increase or decrease; lack of the use of the methods of construction input prices for forecasting, and lack of contractual treatment of the construction inflation during construction period.

Over the last two years, reinforced steel rears prices has been a lead item in inflating construction costs prices as other items followed like windows, doors, electric cables and others. The rise in steel rebar's prices locally and internationally is attributed to numerous economic factors among them: rise of raw materials, increased global demand, and the increase of shipping and insurance costs [7]. As for Saudi Arabia, a market study reported that the rise of steel rebar prices in Saudi Arabia are caused by 80% price increase in steel scrap, 50% price increase in slab in two months, 100% increase in shipping expenses, 300% increase in shipping iron ore, 20% increase in iron ore raw material in addition to marine insurance costs increase, global demand increase of China for importing 38 million tons of steel and iron ore and opening the US market for steel products importers [8]. In Saudi Arabia, one company (a monopoly), Hadeed Co., produces 3.8 million tons of steel rebar, making up for 95% of the total local consumptions for RB steel [8].

The first part of this paper covers a comprehensive survey of international and local RB steel markets, in addition to a review of construction inflation forecasting models as well as contractual treatment of inflation in developed countries. The second part tracks the pattern of historical data of monthly reinforced steel bars prices in Saudi Arabia. In the third part, forecasting models for RB steel price, applicable for two different periods of project durations have been demonstrated. The forecasted RB steel prices were verified against actual data to measure their reliability. The fourth part concludes that the risk of the RB price steel inflation should be borne by the owner and contractor; i.e. the owner will pay more money for the contractor in case of inflated steel prices while the owner pays less money to the contractor in case of deflated steel prices.

### **Literature Survey**

Due to the nature of this research problem, this part covers a survey of international and local RB steel prices, types of forecasting models, and contractual treatment of construction inflation.

#### **International and local RB steel market**

Internationally and locally, there have been recent construction costs inflations, in the range of 10% to 20%, due to the rise in construction materials which are triggered by the rise of the cost of reinforced steel bars (RB) as a lead item. It is reported that the direct impact of inflation of the reinforcing steel bars cost and other construction material costs increase in construction costs by 12-20% in the US for the period November 2003 till November 2004 [7]. At the local level in Saudi Arabia, though not verified, it is reported that inflation of the RB costs ranged between 40% to 100% and that its impact on construction costs is about 7% [9]. The inappropriate mishandling of the inflation by contracting parties in the construction industry has caused enormous damage to the national economy. Losses included the bankruptcy of several contractors, construction projects stoppage and delays, and the delay of commencing several construction projects [9].

To combat the RB steel cost inflation, the Saudi government intervened by preventing exports of RB steel, encouraging local factories to increase their productions, and temporarily waiving tariffs on imported RB steel [10]. In its report, Hadeed Co. [8], which dominates the RB steel market in Saudi Arabia with its market share of 95%, reported that the increase in RB steel and other steel products used in construction is attributed to the following:

1. Annual increase in local demand of 20% for the last two years which surpasses the local production of RB steel.
2. Increase of iron scrape prices by 80% internationally.
3. Increase of the steel alloys and plates prices by 50% in two months.
4. Increase of the iron ore prices by 20% and other related materials by 200%.
5. Increase of marine shipping expenses by 100% in general and by 300% for the iron ore transport.

6. Increase of international demand on construction steel products especially in China which annually imports 38 million tons of RB steel and consumes 380 million tons.
7. Opening the US market for RB steel import.

Al-Wattan Newspaper [11] reported an increase of other construction materials by 40% for PVC and plastic products used as water pipes and windows and doors, by 100% for copper products used as cold and hot water pipes for HAVAC systems, and mentioned that there is an increase in the price of electrical cables and conduits.

#### **Forecasting models of construction cost inflation**

Despite the significance of using forecasting models for construction cost inflation, many of its inputs of material and labor costs do not reflect change in productivity [12]. It is further stated that the forecasting model for inflation does not fit for deflation. Sinha and McKim [13] have applied neural network approach for forecasting construction cost inflation and claimed that this method is more accurate than statistical models of forecasting. However, the model requires a lot of material and labor costs data for a long period of time making it more tedious to use it. Echeverry and Garcia [14] mentioned the limitation of the forecasting techniques for construction cost inflation and their contractual treatment clauses. The authors described a strategy to administer construction cost inflation during the various project phases utilizing expertise of managers and engineers, combining cost accounting and cost control, dealing earlier with suppliers and subcontractors, and using IT technology to control costs.

Hanna and Blair [15] discussed the causes of construction cost inflations and its impact on owners and contractors. They further explained risk allocation criteria in the construction contract, and further they reported some forecasting techniques. For the latter they classified forecasting techniques into three categories: first, descriptive depending on previous experience and they claimed that this technique is widely used in the construction industry. The second category uses time-series forecasting methods based on historical data. The third category is the causal models for forecasting which is widely used in macro-economics studies. Their conclusion is that the time-series forecasting models are the easiest to use given that there is a long historical data of construction costs. Its use is demonstrated on the construction costs indicator for the construction data reported weekly by the US published Engineering News Record Weekly Magazine, for the years 1987-1992.

Blair *et al.* [16] explored the time-series statistical techniques for forecasting construction costs indicator and highlighted its limitation for risk allocation in construction estimating. The authors further divided these techniques into univariate methods and multivariate methods. In their conclusion, the authors recommended the use of those techniques for forecasting construction costs for a short term of a year or less.

Perry [17] discussed the factors that affect the increase in construction costs in general, including material and labor costs inflation. The author recommended the use of the lump sum contract between the construction parties when the inflation rate is low and stable within 5%. He also reported simple mathematical equations for use to compensate the contractors in the admeasurement contracts and indicated the limitation of this method. The author raised an important question of whether a bid is awarded on the least of either constant costs or inflated costs.

Beeston [18] stated that there is almost a unanimous agreement among practitioners that building construction cost data of more than two years or three years should not be considered for forecasting costs. This is due to the fact that the more recent data has much more importance in forecasting present construction costs. The author concludes that despite the abundance of forecasting models for construction costs, there is no best method.

#### **Contractual treatment of construction cost inflation**

In this section, a review is carried out for three important sources for model construction contracts produced by professional institutions that are widely used internationally. Those are of the Institution of Civil Engineers (ICE) in UK, International Federation of Consulting Engineers (FIDIC) in Switzerland, and the World Bank in Washington D.C., USA.

##### **Construction model contracts by ICE**

The British Institution of Civil Engineers (ICE) [19] produced several model construction contracts. In its model contract for civil works between owner and contractor, Provision 65 allows for the treatment of inflation when both parties agree on it [19]. ICE, in cooperation with the Association of Consulting Engineers and the Association of Civil Works Contractors, and in coordination with the British Government, prepared three important documents to deal with construction inflation. These are:

1. Contract Price Fluctuations to deal with civil works. The reference construction cost index is specified by the monthly construction cost indices (civil works) of the Ministry of Environment and published by the British Government Press. These cost indices include labor cost index for civil engineering projects, cost index for procuring and maintenance of construction equipments, and basic material cost index [20].
2. Contract Price Fluctuations for civil engineering works and erecting steel structures [21].
3. Contract Price Fluctuations for erecting steel structures and when civil works are very little. The reference construction cost index is specified by the monthly cost indices (civil works) of the Ministry of Environment and published by the British Government Press. These cost indices include labor cost index in structural steel mills, and labor cost index for erecting structural steel [22].

### Construction model contracts by FIDIC

The International Federation of Consulting Engineers (FIDIC) [23] series of model construction contract clauses became a standard in many countries. Its main contribution is the preparation of model contract conditions which are:

1. Civil Works Contract Conditions (called Red Book)
2. Mechanical and Electrical Works Contract Conditions (called Yellow Book)
3. Owner/Consultant Contract Conditions (called White Book)
4. Build Operate and Transfer Contract Conditions (called Orange Book)
5. Contract Conditions for Small Works.

FIDIC model conditions of contract have dealt with inflation, foreign currency exchange fluctuations and other financial risks. Clause 13.8 of model conditions of contract for building and civil works projects designed by the owner refers to "table of adjustment data" as the completed table adjustment data included in the Appendix to tender [23]. If there is no such table of data, this sub-clause shall not apply. If this sub-clause applies, the amounts payable to the contractor shall be adjusted for rises or falls in the cost of labor, goods and other inputs to the works, by the addition or deduction of the amounts determined by the formula prescribed in this sub-clause. The formula shall be of the following general type:

$$P_n = a + b \frac{L_n}{L_o} + c \frac{M_n}{M_o} + d \frac{E_n}{E_o} + \dots$$

where

"P<sub>n</sub>" is the adjustment multiplier to be applied to the estimated contract value of the work carried out in period "n", this period being a month unless otherwise stated in the Appendix to tender;

"a" is a fixed coefficient, stated in the relevant table of adjustment data, representing the non-adjustment portion in a contractual payment;

"b", "c", "d", ... are coefficients representing the estimated proportion of each cost element related to the execution of the works, as stated in the relevant table of adjustment data; such tabulated cost elements may be indicative of resources such as labor, equipment and materials;

"L<sub>n</sub>", "M<sub>n</sub>", "E<sub>n</sub>",.... are the current cost indices or reference prices for period "n", expressed in the relevant currency of payment, each of which is applicable to the relevant tabulated cost element on the date 49 days prior to the last day of the period (to which the particular payment certificate relates); and

"L<sub>o</sub>", "M<sub>o</sub>", "E<sub>o</sub>",.... are the current cost indices or reference prices for period "n", expressed in the relevant currency of payment, each of which is applicable to the relevant tabulated cost element on the base date.

Until such time as each current cost index is available, the engineer shall determine a provisional index for the issue of interim payment certificates. When a current cost index is available, the adjustment shall be recalculated accordingly. The weightings (coefficients) for each of the factors of cost stated in the tables of adjustment

data shall only be adjusted if they have been rendered unreasonable, unbalanced or inapplicable, as a result of variations.

#### **World Bank construction model contracts**

The World Bank (WB), as an international funding agency, funds all types of infrastructure projects including roads, hospitals, schools, power plants, dams and others all over the world worth of 10 billion US Dollars. Their activities include approving more than 30,000 purchase orders annually for the various projects across the world, and it publishes its good practices [24].

The WB mentioned that there are two basic methods used to counter price fluctuations which occur after bidding: documentary proof or invoice method, and price adjustment formulae [25]. For the first method, it is considered as administratively difficult for the employer to check the validity of invoices, and monitor the occurrence and extent of the contractors claims. For the second method, it states that the application of the formula is dependent upon the availability of reliable indices published at regular intervals to track price movements of basic inputs to the formula. It further appraised the second method as intended for use in a reasonably well-developed environment. With its projects worldwide, the WB adds another correction factor that is of currency exchange rate correction to price adjustment. It provides the exchange rate schedule for its own use.

Of the three methods above, the first, ICE approach, provides construction inflation treatment contractually and quantitatively in simple mathematics which is applicable in the developed countries. The second method of FIDIC adapts the first method and generalizes it for other countries. The third method, World Bank approach, builds on the first method and compounded it with foreign exchange factor using its own indices.

#### **Nature of Construction Contracts Practice in Saudi Arabia**

The construction and building industry of Saudi Arabia and in the Arabian Gulf practice a hybrid British/American style and forms of construction contract and measurement of works. Most of lump sum and admeasurements construction contracts include the bill of quantities as a basis for total bid price and for preparation of interim certificate of payment for measured works. While British-based method of quantity surveying and price estimation is widely used to guide the preparation of the bid, the bill of quantities and/or schedule of prices documents are organized according to the master format system of work classification and code developed by the CSI [26]. This practice has the advantage of measuring the quantities of concrete works at site as built; however, it has the disadvantage of lumping the costs of steel rebar, formwork and concrete together for the reinforced concrete works. This will make it difficult to know in advance the concrete works material and labor components cost breakdown and to evaluate individual components cost data. In our case, this makes it hard to assess and evaluate claims for the inflation of RB steel.

### Estimate of RB Steel Cost Component in a Project

Reinforced concrete structural system types may constitute 30% to 40% of the total costs of a building. As a percentage of building costs, a study showed that the average cost percentage of the structural systems, mainly Cast-in-Place reinforced concrete, for six building types is 24.4% of the total costs [27]. In Saudi Arabia, this cost percentage of Cast-in-Place reinforced concrete system is found to be 33.25% of the total cost for a university college; i.e. institutional building [28]. Furthermore, it is also reported that the cost of a cubic meter of reinforced concrete works is approximately 850 SR, whereas the cost of RB steel component, including material and labor, accounts for 50% of the cost; i.e. 425 SR in 1993 prices (then, RB steel material prices is 1425 SR/ton). Only RB steel material cost component constitutes 30% of the cost per one cubic meter of reinforced concrete; i.e. 255 SR. Subsequently, it can be roughly established that the cost of RB steel for a concrete building or a concrete house can be estimated at:  $0.30 \div 0.35 = 10\%$ , ten percent of the total cost of a house or a building.

### Monitoring international and local trend of steel rebar prices

Table A in the Appendix displays monthly data record for RB steel prices of various bar sizes in Saudi Riyals in the Saudi Arabian market at June 2002 till August 2004 [30]. The difference in RB steel costs for different bar sizes has to do with the demand on each bar size, cost of production and grade of steel. It is found that steel rebar size No. 16 is frequently used by contractors in housing projects, followed by steel rebar size No. 14, No. 12 and the rest. Figure 1 display the price trend, in SR per ton, for most common used steel rebar in reinforced concrete works. It is observed that as the steel rebar size increases, its price decrease. The pricing of each steel rebar is influenced by the demand and cost of production and transportation. For example, the same steel rebar are cheaper by 20% in major cities of the eastern region of Saudi Arabia than the ones in Riyadh. The reason for this disparity is due to the fact that 80% of steel rebar market in Saudi Arabia is produced by one factory, Hadeed Co., located in the eastern region and it is far from Riyadh by 500 km.

Table B in the Appendix displays monthly data record for RB steel prices in Saudi Riyals in the international market for the period June 2002 till August 2004 [30]. For comparison purposes, Fig. 2 shows the prices of RB steel for No. 16 for local prices *vis-a-vis* international prices. If transport costs and import duty are added for imported international steel rebars, then the local and international prices are almost equal

### Forecasting RB Steel Material Prices in Saudi Arabia

Forecasting techniques are almost the only available tool for the contractor to estimate the inflation risk in RB steel price and other construction materials and works. In the following section, we examine the reliability of forecasting RB steel price in Saudi Arabia depending on the duration of the historical data. If the forecasted RB steel price is fairly close to the current RB steel prices, then this tool can be useful. If the

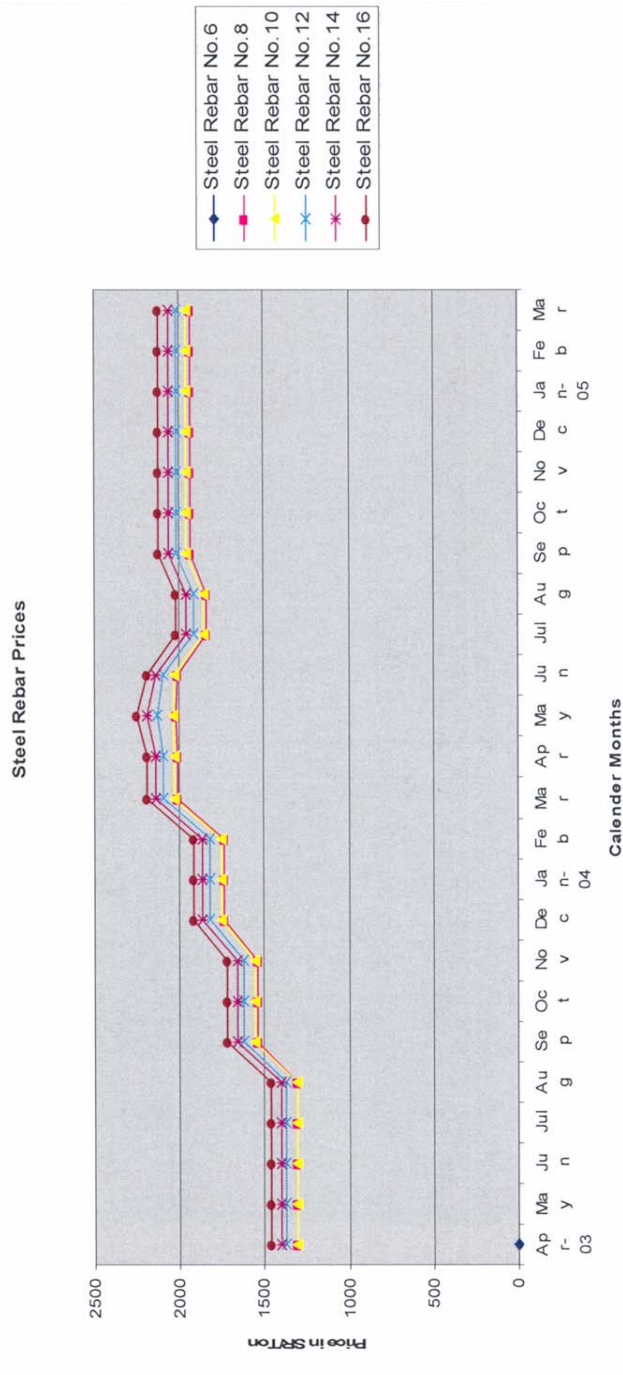


Fig. 1. Steel rebar prices in Riyadh, KSA (in SR/ton).

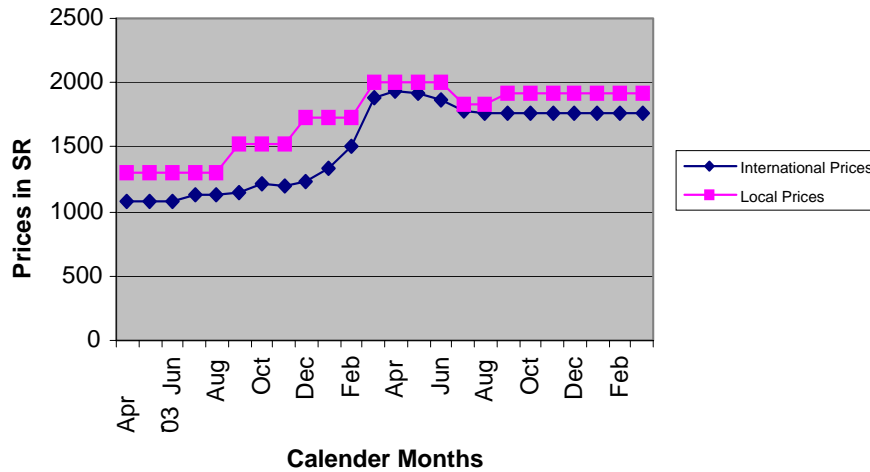


Fig. 2. Internaitonal and local prices of steel rebar in SR/ton.

forecasted RB steel price is not close enough to the current prices, then the contractor has no other means to estimate the inflation or deflation of the RB steel price.

#### Scenario I: Forecast of one year based on previous price data (case i: over-estimate substantially)

Monthly RB steel cost data in Riyadh city is available for the period January 2003 till September 2005 as shown in Table A in the Appendix. For the first scenario of using forecasting techniques, we use the first 12 months RB steel cost data profile for the year 2003 and find the best-fit curve to represent it. Using MS Excel, best-fit functions feature were used for this cost data. Subsequently, Table 1 column two shows the types equations used, and those are: linear, logarithmic, polynomial, power and exponential. Column 3 displays the mathematical formulas best fit for the cost data. Column 4 presents R Square value for each type of equation. The five previous equations are compared based on their highest R Square, and the latter reflects the level of accuracy of representing the real data pattern. R Square is an indicator on how much variability of the data explained by a model. The highest R Square for any best-fit-curve function is the more accurate in representing the real data. Therefore, by looking at Table 1, the polynomial equation is the best forecasting technique for its R Square highest value of 0.8986. Figure 3 shows the various curves profile for the year 2003 price data of the RB steel in Riyadh.

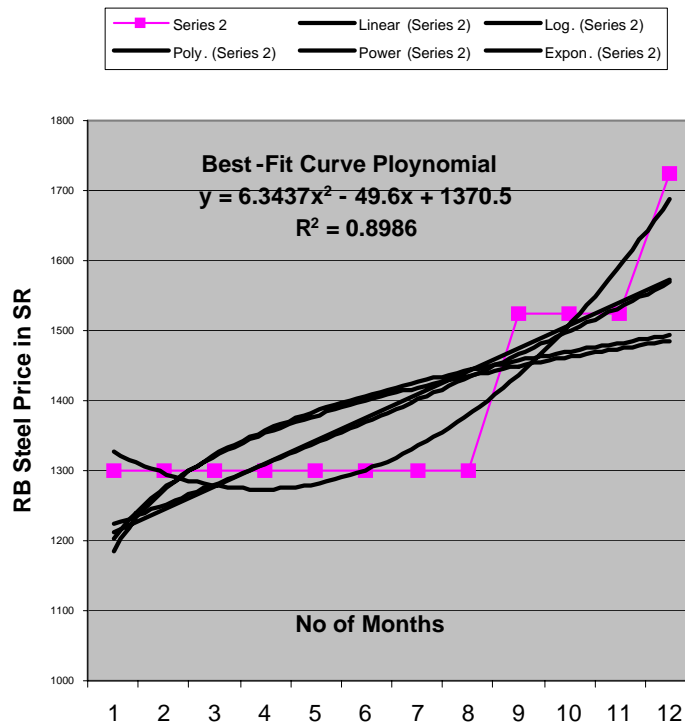
**Table 1. Display of best-fit-curves for the monthly RB steel cost data for year 2003 + year 2004**

No.	Type of Forecasting Technique	Formula	R Square
(1)	(2)	(3)	(4)
1	Linear	$y = 32.867x + 1178$	0.6668
2	Logarithmic	$y = 123.47\text{Ln}(x) + 1186$	0.4135
3	Polynomial	$y = 6.3437x^2 - 49.6x + 1370.5$	0.8986
4	Power	$y = 1202x^{0.0852}$	0.4216
5	Exponential	$y = 1196e^{0.0226x}$	0.6757

Best-fit-curve, of RB steel price, is of polynomial as follows:

$$Y = 6.3437x^2 - 49.6x + 1370.5 \tag{1}$$

where Y is the RB steel price  
x is the month number



**Fig. 3. Various curve-fit profile of RB steel prices of rthe year 2003.**

When a construction contractor prepares a bid in December 2003 and used the above equation to forecast his RB steel price in reinforced concrete, it works over the whole year 2004. The variance of RB steel price during the year 2004 it is shown in Table 2 while Fig. 4 highlights that the variance increase per unit price of RB steel price increase with time.

**Table 2. Monthly roreasted RB steel prices for the year 2004**

No. of month	Forecasted month	Actual RB steel price in SR/ton	Forecasted RB steel price in SR/ton	Difference between Forecasted ad Actual Prices
(1)	(2)	(3)	(4)	(5)
1	January 2004	1725	1797.7853	72.7853
2	February 2004	1725	1919.4652	194.4652
3	March 2004	2000	2053.8325	53.8325
4	April 2004	2000	2200.8872	200.8872
5	May 2004	2010	2360.6293	350.6293
6	June 2004	2000	2533.0588	533.0588
7	July 2004	1825	2718.1757	893.1757
8	August 2004	1825	2915.98	1090.98
9	September 2004	1925	3126.4717	1201.4717
10	October 2004	1925	3349.6508	1424.6508
11	November 2004	1925	3585.5173	1660.5173
12	December 2004	1925	3834.0712	1909.0712

Thus, RB steel price forecasted for December 2004; i.e.  $x$  at 24, there will be overestimate of RB forecasted steel price than the actual by the following amount; by substituting values for Eq. (1).

$$\begin{aligned} \text{At } x = 24, Y &= 6.3437 * 24 * 24 - 49.6 * 24 + 1370.5 \\ &= 3834.07 \text{ SR/ton (last entry of column 4 in Table 2)} \end{aligned}$$

Therefore, the difference between forecasted RB steel price and actual prices per ton is:

$$\begin{aligned} \text{Unit Difference} &= 3834.07 \text{ SR/ton} - 1925 \text{ SR/on} \\ &= 1909.07 \text{ SR/ton (last entry of column 5 in Table 2)} \end{aligned}$$

So, if there is an order of 1000 tons of RB steel in December 2004, then the overestimate will be 1,91 million SR which is very high and exaggerated.

### Forecasted RB Costs in SR/Ton Based on 12 Months History

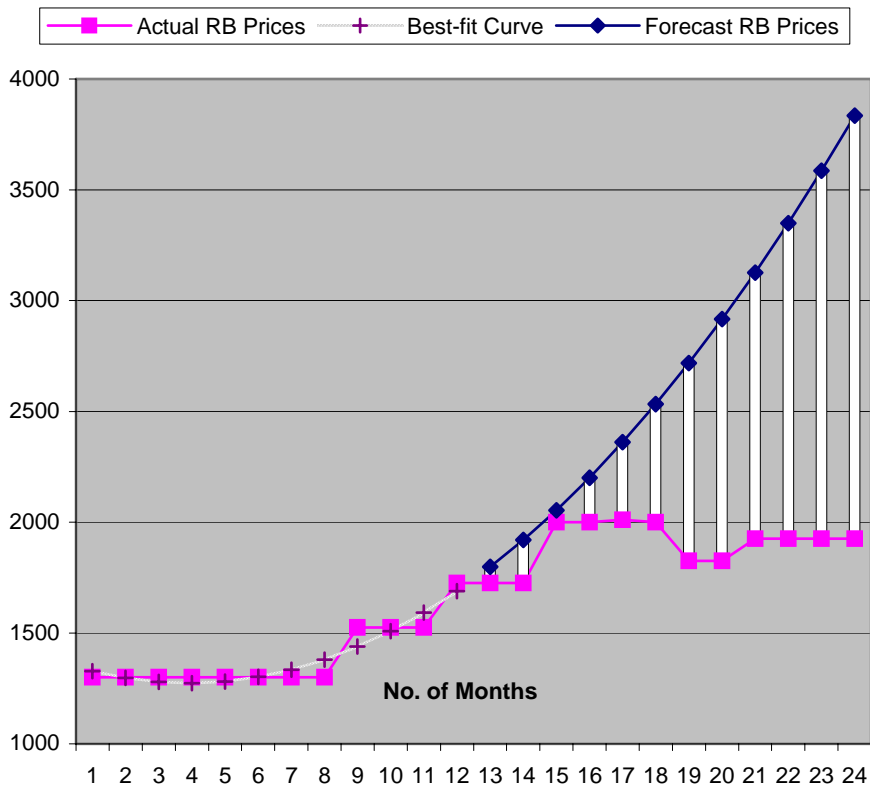


Fig. 4. Plot of forecasted RB steel prices versus actual prices of rthe year 2004.

The shaded area in Fig. 4 shows the rise of the variance between the forecasted versus the actual prices, and is increasing with time making the contractor over-estimating the forecasted RB steel prices by using the easiest and most appropriate mathematical approach.

**Scenario II: Forecast of one year based on price data for the last two years (Case II: Over-estimate marginally)**

Monthly RB steel cost data in Riyadh city is available for the period January 2003 till September 2005 as shown in Table A in the Appendix. In the second scenario of

using forecasting techniques, we use the first 24 months, of the years 2003 and 2004 RB steel cost data profile and find the best-fit curve to represent it. Using MS Excel best-fit feature, Table 3 shows a summary of five equations with their type spelled in column 2, its formula in column 3, and its R Square in column 4. These equations, best-fit-curve, can be compared based on their highest R Square. The polynomial equation has chosen the best forecasting technique for its highest value of R Square of 0.8448. Figure 5 shows the various curves profile for the first 24 months of the years 2003 and 2004 and cost data of the RB steel in Riyadh.

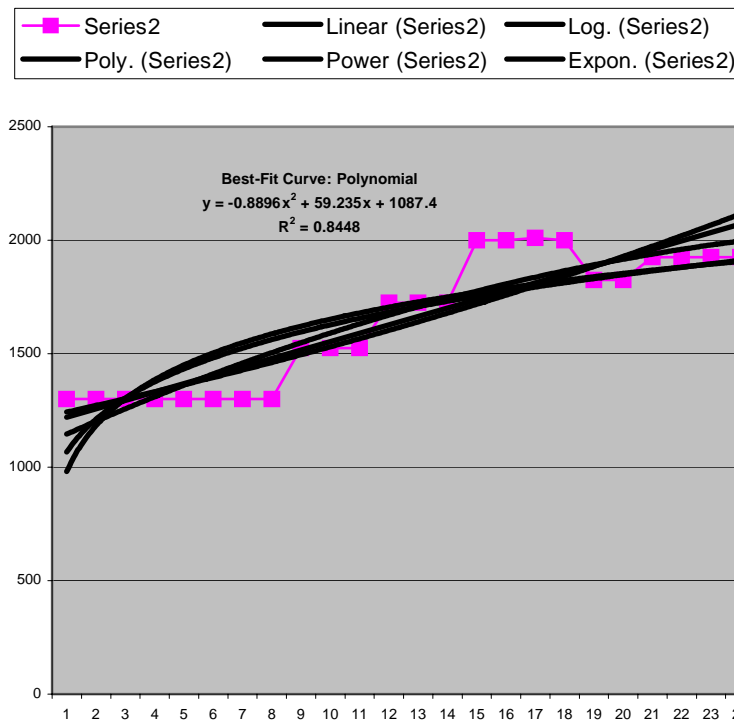


Fig. 5. Various curve-fit profile for RB steel prices for the years 2003 and 2004.

Table 3. Display of best-fit-curves for the monthly RB steel cost data for the year 2003 + 2004

No.	Type of forecasting technique	Formula	R Square
(1)	(2)	(3)	(4)
1	Linear	$y = 36.996x + 1183.8$	0.8266
2	Logarithmic	$y = 291.32\ln(x) + 981.26$	0.707
3	Polynomial	$y = -0.8896x^2 + 59.235x + 1087.4$	0.8448
4	Power	$y = 1066.6x^{0.1835}$	0.7243
5	Exponential	$y = 1214.5e^{0.0231x}$	0.834

Best-fit-curve, of RB steel price, is of polynomial as follows:

$$Y = -0.8896x^2 + 59.235x + 1087.4 \quad (2)$$

where Y is the RB steel price  
x is the serial month number

When a construction contractor prepares a bid in December 2004 and used the above equation to forecast his RB steel price in reinforced concrete, it works over the months January-September of 2005; i.e. for 10 months. The variance of RB steel price during the year 2005 is shown in Table 4, while Fig. 6 highlights that the variance increases per unit price of RB steel price with time. Thus, RB steel price forecasted for 10 months till October 2005,  $x = 33$ , is found to be an over-estimate of RB forecasted steel price than the actual. The difference is calculated by substituting values for variables of Eq. 2 minus the real monthly RB steel cost data.

**Table 4. Monthly forecasted RB steel prices for the year 2005**

No. of Month (1)	Forecasted month (2)	Actual RB steel price in SR/ton (3)	Forecasted RB steel price in SR/ton (4)	Difference between forecasted ad actual prices (5)
1	January 2005	1925	2012.275	87.275
2	February 2005	1925	2026.1404	101.1404
3	March 2005	1925	2038.2266	113.2266
4	April 2005	1925	2048.5336	123.5336
5	May 2005	1925	2057.0614	132.0614
6	June 2005	1925	2063.81	138.81
7	July 2005	1925	2068.7794	143.7794
8	August 2005	1825	2068.7794	243.7794
9	September 2005	1825	2071.9696	246.9696

For example, at: At  $x = 33$ , then

$$\begin{aligned} Y &= -0.8896*33*33- 59.235*33 + 1087.4 \\ &= 2071.9696 \text{ SR /Ton (last entry of column 4 in Table 4)} \end{aligned}$$

Therefore, the difference between forecasted RB steel price and actual prices per ton is:

$$\begin{aligned} \text{Unit Difference} &= 2071.9696 \text{ SR/ton} - 1825 \text{ SR/ton} \\ &= 246.9696 \text{ SR/ton (last entry of column 5 in Table 4)} \end{aligned}$$

So, if there is an order of 1000 tons of RB steel in September 2005, then the over-

estimate will be 247,000 SR which is high and exaggerated.

**Forecasted RB Costs /Ton  
Based on 24 Months History**

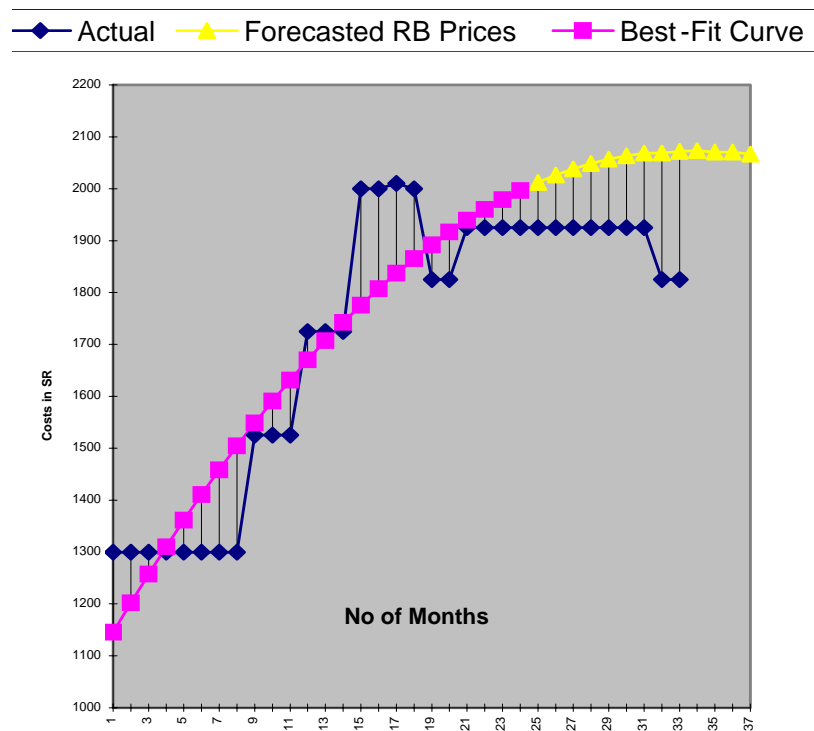


Fig. 6. Plot of forecasted RB steel prices versus actual prices of the year 2005.

That shaded area in Fig. 6 shows the rise of the variance between the forecasted versus the actual prices with time, making the contractor over-estimating the forecasted RB steel prices by using the easiest and most appropriate mathematical approach. It is clear that the second scenario of the forecasting model is more accurate than the one for the first scenario since it incorporates more historic data.

In the final analysis, both scenarios of forecasting models yield an over-estimated price for the RB steel price. These two scenarios show the weakness of this approach; and such a method may not be in the interest of the owner. In conclusion, the risk of RB steel price inflation should be born by the owner when there is an over-estimate and by the contractor when there is an under-estimate since it is difficult for the contractor to quantify without exaggeration.

### Conclusion

In the current construction practice in Saudi Arabia, there is no treatment of RB steel price inflation. Subsequently, many contractual disputes have occurred during the recent increase in RB steel prices. To address this problem, this paper carries first a survey of international and local RB steel prices, review of construction inflation forecasting models, and review of contractual treatment of inflation in the developed countries. Given the real data for the RB steel price in Saudi Arabia, two different periods of project durations have been chosen to apply forecasting techniques. The results showed us that the more historical data available within two year frame, the more accurate is the model predicting future RB steel prices. However, in both cases, it is shown that the forecasting models, being the only available tool for the contractor to predict future prices for the RB steel, has failed. Therefore, it is concluded that the risk of the RB price steel inflation should be borne by the owner and contractor; i.e. the owner will pay more money for the contractor in case of inflated steel prices while the owner pays less money to the contractor in case of deflated steel prices. Subsequently, further research should address the risk sharing between owners and contractors.

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## Appendix

Table A. Local steel rebar prices in SR/Ton

Date	Bar Size					
	6	8	10	12	14	16≥
<b>January 2003</b>	1460	1400	1375	1310	1310	1300
<b>February</b>	1460	1400	1375	1310	1310	1300
<b>March</b>	1460	1400	1375	1310	1310	1300
<b>April</b>	1460	1400	1375	1310	1310	1300
<b>May</b>	1460	1400	1375	1310	1310	1300
<b>June</b>	1460	1400	1375	1310	1310	1300
<b>July</b>	1460	1400	1375	1310	1310	1300
<b>August</b>	1460	1400	1375	1310	1310	1300
<b>September</b>	1720	1660	1620	1555	1535	1525
<b>October</b>	1720	1660	1620	1555	1535	1525
<b>November</b>	1720	1660	1620	1555	1535	1525
<b>December</b>	1920	1860	1820	1755	1735	1725
<b>January 2004</b>	1920	1860	1820	1755	1735	1725
<b>February</b>	1920	1860	1820	1755	1735	1725
<b>March</b>	2195	2135	2095	2030	2010	2000
<b>April</b>	2195	2135	2095	2030	2010	2000
<b>May</b>	2250	2190	2130	2040	2020	2010
<b>June</b>	2195	2135	2095	2030	2010	2000
<b>July</b>	2020	1960	1920	1855	1835	1825
<b>August</b>	2020	1960	1920	1855	1835	1825
<b>September</b>	2120	2060	2020	1955	1935	1925
<b>October</b>	2120	2060	2020	1955	1935	1925
<b>November</b>	2120	2060	2020	1955	1935	1925
<b>December</b>	2120	2060	2020	1955	1935	1925
<b>January 2005</b>	2120	2060	2020	1955	1935	1925
<b>February</b>	2120	2060	2020	1955	1935	1925
<b>March</b>	2120	2060	2020	1955	1935	1925
<b>April</b>	2195	2135	2095	2030	2010	2000
<b>May</b>	2250	2190	2130	2040	2020	2010
<b>June</b>	2195	2135	2095	2030	2010	2000
<b>July</b>	2020	1960	1920	1855	1835	1825
<b>August</b>	2020	1960	1920	1855	1835	1825
<b>September 2005</b>	2020	1960	1920	1855	1835	1825

Source: Al-Muhadib for Steel Supplies (2005), Riyadh, Saudi Arabia

**Table B. International Prices for Steel Rebars (FOB) in US \$/ Ton**

Date	Hot Rolled Coil	Hot Rolled Plate	Cold Rolled Coil	HD Galv. Coil	Electro Zinc Coil	Wire Rod (mesh)	Structural Sections & Beams	Rebar (16 mm)	Merchant Bar
June 2002	304	302	363	431	420	265	335	255	272
July	319	312	390	455	438	273	343	264	279
August	320	313	391	456	440	273	344	264	280
September	319	318	396	462	439	273	340	263	282
October	318	316	398	466	445	270	334	257	281
November	322	318	401	469	448	271	335	255	283
December	317	318	399	465	447	268	332	255	282
January 2003	333	327	411	479	463	276	338	263	295
February	339	333	420	489	470	289	356	275	307
March	340	332	424	494	473	300	362	286	313
April	340	335	426	490	469	296	361	286	309
May	336	342	425	492	476	301	367	289	313
June	333	346	425	489	476	302	373	289	316
July	329	346	421	487	471	303	372	302	317
August	327	343	418	483	467	300	369	300	314
September	333	346	420	478	464	299	372	308	322
October	341	357	430	490	474	314	386	323	335
November	343	361	427	490	475	315	390	318	342
December	354	367	434	502	488	323	403	327	353
January 2004	386	400	474	546	524	348	443	355	391
February	414	432	501	573	547	396	482	404	422
March	474	506	563	650	631	479	544	503	511
April	513	540	596	682	654	498	585	517	543
May	549	575	614	706	681	498	594	511	547
June	571	602	649	739	715	492	591	496	541
July	585	633	665	754	736	483	584	474	535
August	580	627	659	747	728	478	578	470	530
September	640	704	709	796	768	494	616	511	546

Source: MEPS International Ltd. (2004).

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**ملخص البحث.** حديثاً، ارتفعت أسعار أسياخ حديد التسليح المستخدم بالحرسنة المسلحة والحرسنة سابقة الصب، محلياً وعالمياً بشكل متزايد حتى بلغت أكثر من ٥٠٪ في سنة واحدة، مما أدى إلى زيادة في أسعار وكلفة البناء. وقد أدى الارتفاع المفاجئ في أسعار حديد التسليح إلى ارتفاع أسعار مواد البناء الأخرى مثل الكابلات، والحرسنة الجاهزة، ومواد البلاستيك وغيرها.

ويعزى تضخم أسعار حديد التسليح إلى عدة عوامل اقتصادية منها ارتفاع أسعار الحديد الخام، وارتفاع الطلب العالمي، وارتفاع كلفة النقل البحري والتأمين البحري. إن اقتصاد دول الخليج العربي يعتمد كلياً على صادرات البترول، كما أن نسبة تضخم أسعار السلع منخفضة جداً، وتبعاً لذلك فقد أدى ارتفاع كلفة البناء المفاجئة إلى حدوث نزاعات تعاقدية ومطالبات مالية بين أطراف عقود البناء من ملاك ومقاولين.

يهدف هذا البحث إلى رصد ارتفاع أسعار حديد التسليح للسنتين الأخيرتين في المملكة العربية السعودية، وتقديم نموذج رياضي للتنبؤ في أسعار حديد التسليح المستقبلية. إن بإمكان كل من الملاك، والاستشاريين الهندسيين، والمقاولين أن يستخدموا النموذج المقترح كأداة (١) لاستقراء أسعار حديد التسليح المستقبلية، و(٢) إضافة وتطبيق بند في الشروط العامة للعقد لتعويض المقاول.

