Causes, Effects, Benefits, and Remedies of Change Orders on Public Construction Projects in Oman

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Abstract: Change orders are usually issued to cover variations in scope of work, material quantities, design errors, and unit rate changes. This paper discusses variations in public construction projects in Oman by investigating causes of variations, studying their effects on the project, identifying the beneficial parties, and suggesting remedies to alleviate related problems. Tasks included an analysis of four actual case studies and conducting a field survey via a questionnaire. It was determined that the client's additional works and modifications to design were the most important factors causing change orders, followed by the nonavailability of construction manuals and procedures. The most important effects of change orders on the project were found to be the schedule delays, disputes, and cost overruns. The contractor was found to be the party most benefiting from the change orders followed by the consultant and then the client. A set of remedial actions were suggested and respondents viewed that the revision of registration of consulting offices would be the most important action followed by establishing standard documents for design procedures and building a national database about soil conditions and services.

DOI: 10.1061/(ASCE)CO.1943-7862.0000154

CE Database subject headings: Construction management; Change orders; Delay time; Project management; Costs; Oman; Case studies.

Author keywords: Construction management; Change order; Delay; Project completion; Cost overrun, Oman.

Introduction

Changes during construction of projects are inevitable in most construction projects and change orders are issued to correct or modify the original design or scope of work. The corrections or modifications are carried out for many reasons including changes in scope made by the client and as a result of change requests made by the consultant due to design errors or new findings. The contractor makes use of the different interpretation of the contract clauses or loose ends in the scope or design to improve his profit margin. Most of change orders issued during the construction period are major causes of time and cost overruns, disruption, and disputes. In some cases, change orders cause confusion and lead to detrimental effect on the environment. Yet, no unique method is available for avoiding or managing them effectively. The conventional approach is to include a percentage of the project cost as a contingency in the contract budget for their occurrence.

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Note. This manuscript was submitted on December 19, 2008; approved on September 18, 2009; published online on September 19, 2009. Discussion period open until October 1, 2010; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 136, No. 5, May 1, 2010. ©ASCE, ISSN 0733-9364/2010/5-615–622/$25.00.

Kaming et al. (1997) studied influencing factors on thirty one high-rise projects in Indonesia and found that design changes is one of the most important factors causing time overrun. They stated that "design changes inevitably lead to variation in original cost/time programmes." Al-Momani (2000) found that user changes are one of the main causes of delay in 130 public projects in Jordan. Goudreau (2001) reported five key elements that burden projects; they are: payments, authority, change order, schedule of the work, and contract documents. Memon (2004) divided the causes of delay into two broad categories: excusable delays and nonexcusable delays. Excusable delays were more oriented to the client or consultant causes, while the nonexcusable delays were related to the contractor. Design change was mentioned as a cause in excusable delays. He suggested a list of remedies for the causes of both categories. Acharya et al. (2006) carried out field survey and identified six construction conflicting factors pertinent in Korean context. Change order was the third factor causing conflict in construction projects. Sambasivan and Soon (2007) conducted a questionnaire survey in Malaysia and identified ten causes of delay. The first three causes were: contractor's improper planning, contractor's poor site management, and inadequate contractor's experience. Arun and Rao (2007) reported that changes in design as well as defects and correction in design as factors that resulted in cost and time overruns. Assaf and Al-Hejji (2006) conducted a field survey on time performance of different construction projects in Saudi Arabia. They identified 73 causes of delay in the 76 projects surveyed, but the most common cause of delay identified by all three parties (clients, consultants, and contractors) was the "change order." Wu et al. (2005) studied the causes of 1,038 change orders issued for a national highway project in Taiwan. Their study revealed that the design insuffi-

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Table 1. Cost Values of Change Orders for Case Studies

Case number	Original cost R.O. (US$)	C.O.1 R.O. (US$)	C.O.2 R.O. (US$)	C.O.3 R.O. (US$)	C.O.4 R.O. (US$)	Total C.O./ original cost (%)
1	17,455,110 (44,987,397)	1,293,535 (3,333,853)	635,523 (1,637,947)	85,213 (219,622)	907,929 (2,340,023)	16.74
2	2,779,963 (7,164,853)	1,360,000 (3,505,155)	336,467 (867,183)	240,000 (618,557)	—	69.66
3	2,838,778 (7,316,438)	17,147 (44,193)	401,084 (1,034,720)	592,499 (1,527,060)	—	35.6
4	25,211,207 (64,977,338)	−1,483,612 (−3,823,742)	638,837 (1,648,186)	136,557 (351,951)		−2.81

ciency of geologic survey, site survey, and planning are the major causes of change orders. Serag and Oloufa (2007) developed a statistical model to quantify the increase of the contract price due to change orders. The model was tested on 29 observations from four projects. Results showed average percentage of error of 28.61% compared to the actual price increase. Serag et al. (2008) developed a model to quantify the productivity loss of piping work due to the change orders. They analyzed two sets of data: the first included all predictor variables which both parties, the owner and the contractor, contributed to the productivity loss, and the second one included the predictor variables, from the legal viewpoint, only the owner is responsible for. The model can be used by both the owner and the contractor to quantify the productivity loss due to change orders. Akpan and Igwe (2001) stated that the causes of project variations are well known, but the methodology used in handling them is inadequate. They believed that a project's cost overrun is due to inflation, inadequate analyzes, and inadequate information. Ibbs (1997) found that changes have tremendous effects on the performance of construction projects and a whole industry has been developed to fight change orders' claims and disputes. Hanna et al. (2002) stated that the more variations in a project, the higher the probability the project to be impacted and to have significant productivity losses. They calculated a probability of 54.8% that a project would be impacted by variations. Chan and Kumaraswamy (1997) carried a comparative study of causes of time overruns in Hong Kong construction projects and compared the results with those found in Saudi Arabia and Nigeria. They found that the client-initiated change orders are one the major causes of time overrun. Perkins (2007) examined the causes for construction phase changes in 23 private design/build and 20 government design/build construction projects in the United States. He found that changes might arise from: owner-requested additions/deletions to the work; the action of third parties beyond the control of the owner or contractor; delays in owner-supplied access or equipment; differing site conditions; and discrepancies in the original design specifications. He reported that the number of changes due to design error in design/build construction is statistically significantly lower than that of the design-bid-build construction. Lee (2008) studied the data of 161 completed transport projects. The results indicated that 95% and 100% of road and rail projects, respectively, had a maximum cost overrun of 50%. The key causes of cost overruns were found to be: changes in scope; delays during construction; unreasonable estimation and adjustment of project costs; and no practical use of earned value management system. Chen and Hsu (2007) used a hybrid artificial intelligence with a cased based reasoning model using Artificial Neural Networks (ANN) to analyze 340 accepted litigation collected by supreme courts and appellate courts in 48 states and one district of the United States. Their aim was to create a new approach to prevent severe disputes caused by change orders. They found that their program was 84.61% accurate to identify possible litigation in relatively small projects (less than US$1 million).

It is clear from the above literature and others that change orders are a major cause for cost and time overruns. However, the reasons for change orders differ from one country to another or even between one project and another. Due to many known technical and political reasons, construction projects in developing countries receive more change orders than projects in developed countries. Changes in construction projects in Oman appear in terms of the scope of work, major variations in the quantities, and changes in the design, delay, and unit rate. This research investigated the causes and effects of change orders in four construction projects in Oman used as case studies. The research also investigated how different parties (client, consultant, and contractor) deal with these problems through results obtained from a field survey conducted via a questionnaire's respondents from the three concerned parties. Remedies for such problems are recommended to alleviate variation's effects on public construction projects in Oman. It is hoped that the findings and the suggested remedies will be helpful to project planners, design consultants, and decision makers.

Case Studies

In this section, a summary of four typical case studies representing water transmission, roads, buildings, and ports projects carried out by the Government of Oman. Traditional method (design-bid-build) was used as delivery system for all of the projects discussed in the four case studies; where the client hires a consultant for the design and then a contractor is selected by means of tendering process. All of the presented case studies are of the unit price type projects. Clause 55 (estimated quantities) and clause 56 (actual and correct quantities) of the Standard Document for Building and Civil Engineering Works (Ministry of Finance, Oman 1999) are used for substructure and superstructure respectively. Clause 55 allows the quantities to be re-measured due to actual site conditions, errors, and omissions in the Bill of Quantities and variations. Table 1 shows the cost overruns and

Table 2. Time Extension due to Change Orders for Case Studies

Case number	Original time (days)	Total time extension (days)	Time extension/ original time (%)
1	607	52	8.57
2	365	365	100
3	730	153	21
4	825	273	33.1

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Table 2 gives time overruns due to change orders in all of case studies.

Case Study No. 1: Water Transmission Project

The scope of work consisted of construction, commissioning, and putting into commercial operation of a Water Transmission Project including three water storage reservoirs, different water transmission pipelines, and pumping stations. This project was part of a larger project for a sea water desalination plant that was carried out by different contractors. Four change orders were issued as follows:

Change Order No. 1 was issued to cover the costs of rerouting the pipeline due to the right-of-way of a main highway and to changing of the water storage foundations from raft footing to piles. Due to the delay caused by Change Order No. 1 and the commitment of the government to buy the desalinated water from the supplier and bowser it to consumers, *Change Order No. 2* was issued to cover the cost of leveling the area between the desalination plant and the reservoirs and the construction of a filling station and a guardhouse, which were not included in the original scope.

Change Order No. 3 was issued to cover the cost of delay paid for preliminary items such as facilities at the site, insurance, and others. *Change Order No. 4* was issued for rerouting the pipeline from passing through private farms and houses.

The above changes' cost was about R.O. 2.922 M (US$7,539,216), which was 16.74% of the original contract value. These variations can be classified into two groups, i.e., consultant-related and client-related. The first group included the variations issued due to design errors in the routing of the pipeline and change in the footing design. The second group included the variations issued due to additional scope requirements, which encompassed the construction of a water filling station and a guardhouse and the leveling of the area between the reservoir and the desalination plant. The first type could have been avoided by proper soil investigation, field survey of the route, knowledge of the local regulations (i.e., Ministry of Transportation and Communications), and coordination with other authorities (i.e., Ministry of Housing). The second type could have been minimized by proper planning and phasing of the projects. It is clear that the consultant's related causes have greatly contributed to the client's related causes. In addition to the cost increase, an 8.57% time extension was granted.

The total cost of variations exceeded the available contingency. In Oman, such problems are tackled by either requesting additional funds from the concerned government authority or by transferring money from other projects. The first solution is time consuming and almost always causes an additional delay to the project, while the second solution leads to reduction in the scope of the other projects or postponing them until additional funds are allocated. This shows how variations could disrupt an owner's plans and confuses the management of the project. In addition, it could become more complicated if the owner could not get additional funds as the project could be suspended for unknown period.

Case Study No. 2: Building Project

The original scope of work for this project consisted of the construction of two typical class room buildings: A and B of three floors each. Each building has an approximate total floor area of 7,660 square meters. Change Order No.1 was issued when the client decided to construct a third Building C similar to Buildings A and B, although serving a different function including offices, meeting halls, language labs, etc.

Due to the different use of Building C, the design was modified resulting in a larger space area (9120 m^2), and scopes including structural, air condition, doors, windows, plumbing, electrical, etc. Therefore, Change Order No. 2 was issued.

During construction, the client realized that the available budget cannot cover the cost, and he instructed a reduction in the scope, which resulted in demolition of a large number of internal partitioning walls. However, near completion of works, the client decided to reparation the floors to create as many offices as possible, which resulted in issuing Change Order No. 3 and a large time overrun.

This case study indicated that there was no proper planning for the new building, and changes to the scope of work were not evaluated properly before the contractor was instructed to execute the work based on the new changes. It could be also noticed that the changes disrupted the continuity of the work because the contractor was required to demolish and reconstruct some of the work several times. Thus, the final cost of Building C was increased from RO 1,360,000 (US$3,508,772) to RO 1,936,467 (US$4,996,045), which is 42.4% more than the original cost. The project construction time was doubled.

The above problems could have been avoided by a better definition of the client's needs within the available budget. Also, the consultant should have advised the client on the implications of changes and explained the effects of the possible scenarios on the project's progress and cost.

Case Study No. 3: Road Project

The scope of work comprises a construction of a 74 km asphalt road. The road was designed to follow the same route of an existing track road. Change Order No. 1 was issued to construct a temporary earth road to divert the traffic during construction.

During construction, Sabkha soils (coastal sediments with a high salt content and low bearing capacity) were encountered for a depth of more than 80 cm in some locations of the road's route. Based on this, the consultant redesigned the road's cross section which included additional excavation and the use of geo-grid reinforcement for the embankment. This modification resulted in Change Order No. 2. The net effect of Change Orders No. 1 and 2 exceeded 10% of the contract value, which gave the right to the contractor to claim new unit rates for the additional quantities of excavation and borrow materials. Accordingly, Change Order No. 3 was issued.

Two major mistakes were committed by the consultant: (1) no proper geotechnical investigation was carried out to assess the extent of the quantities and depth of the Sabkha soil and (2) construction of a temporary road was not considered in the design phase. These mistakes led to the cost of the project being increased by R.O. 1,010,730 (US$2,607,663), which is 35.6% more than the original cost. These risks could have been minimized by implementing a proper engineering inspection and design.

Case Study No. 4: Port Project

The scope of work comprises the construction of 4.2 km of breakwaters for a sea port and a fishery harbor. The main construction activities include dredging to replace ground at the toes of the

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breakwater; ground replacement, disposal of the dredged material, and construction of rock core, rock armor, concrete armor, and concrete crest walls.

After awarding the project, it was found that changing the method of construction of the breakwater using CORE-LOC Armour instead of STABIT Armour units, as specified, will result in cost savings. The client entered into negotiation with the contractor that resulted in cost savings of Change Order No. 1.

Change Order No. 2 and one month time extension were issued to cover client's decision to relocate the port entrance; modification to the design of the breakwater to cater for vehicles' access to future bulk liquid berths; passing bays; turning bays; and providing of navigation lights on the breakwater roundheads.

During construction, the contractor was instructed to stop the works pending client's decision on some modification which resulted in Change Order No. 3.

The variations issued in this case study started before the commencement of the construction, when the owner discovered the savings that he could make by changing the method of construction of the breakwater. Therefore, he agreed to share the savings with the contractor. This shows a pitfall in the feasibility study done by the consultant to investigate the most cost-effective design alternative for the project. The cost saving could have been much more and the client did not have to share it with the contractor. Also, no time wastage should have been incurred due to the change in the method of construction.

The same reasoning applies to the second variation cost paid to relocate the port entrance, and to modify the breakwater to cater for vehicles' access to future bulk liquid berths. This variation gives a feeling that the objective of the project was not clear during the design stage or the design of the breakwater did not consider the size of the vehicles that will use the port. The causes for this variation are not clear, but the consultant was supposed to be the professional party who advises the owner on the best design and specifications for the project, assuring that the owner has a clear plan for his needs.

The third variation shows the uncertainty of the owner's requirements or the unavailability of budget to cover all the costs of the project. The extension of time shows that the period (period pending instruction) spent by the owner to make a decision on whether to go ahead and construct the fishery harbor or not had incurred an additional variation.

Field Survey

Based on the case studies discussed above, it is clear that change orders in construction projects are largely causing time/cost overrun, which required detailed analysis in a form of filed survey. The questionnaire was one of the tools used to obtain feedback from the clients, consultants, and contractors for the causes, effects, and beneficial parties and suggested remedies to changes issued in construction public projects implemented in Oman.

Questionnaire's Methodology

The questionnaire included 42 statements, which were divided into four sections. Sections I and II dealt with the causes and effects of the variations on construction projects, respectively, whereas Sections III and IV sought the opinion of the three parties on the benefiting party from variations and suggested remedies, respectively. A five-point Likert scale ranging from 1 (strongly disagree) to 5 (no comment) was adopted to capture the opinion of respondents on the causes and effects, benefiting parties and suggested remedies. The remedies were suggested by the writers based on the knowledge gained from the four case studies, discussions held with concerned parties, and previous industrial experience. The causes were categorized into four groups: client-related, consultant-related, contractor-related, and others.

The questionnaires were distributed to 30 clients, 25 contractors, and 20 consultants who are involved in similar types and sizes of projects presented in the above case studies. The clients were all selected from the government agencies because the case studies were all government projects. The questionnaire statements were prepared based on experience and discussions with different parties. They are similar to statements presented in different literature. The questionnaires were distributed at the same time and took about two months to collect all the responses. To ensure a well representation of the answers, only one set of questionnaire was given to each client, consultant, and contractor. The questionnaires were distributed by hand with a covering letter explaining the purpose and importance of the study. This was augmented by face-to-face discussions and phone conversations to explain the questions and to reply to queries. This was conducted to ensure that all respondents interpreted the questions in a similar manner and received the same information. Out of the distributed questionnaires, 17, 14, and 12 responses were received and they represented clients (57%), consultants (56%), and contractors (60%), respectively. Most of the respondents were senior engineers and project managers who spent at least four years in the construction industry in Oman.

The relative importance index (RII) was calculated using the following equation. This equation was used to calculate the importance of factors according to survey responses

$$\mathrm{RII} = \frac{\sum W}{HS} * 100$$

where W=weighting of each factor by respondents ranging from 1 to 5; H=highest weight (i.e., 5 in this case); and S=sum of all respondents from strongly disagree to no comment.

The analysis of questionnaire respondents was mainly done by calculating the RII. The RII was used as a ranking technique to each statement in order to compare the responses received from the three parties (i.e., client, consultant and contractors). This was done for each section of the questionnaire (i.e., causes, effects, benefiting parties and remedies). In addition, an overall analysis was carried out to compare the results of the individual group with the overall results. Standard deviation (SD) was calculated for the relative importance to determine the dispersion of relative importance values around the mean.

Discussion of Results

A discussion of the major causes of variations, the major effects of variations on the project and benefiting parties, is presented below.

Causes of Change Orders

Table 3 presents the RIIs and ranks of each cause based on responses received from the three parties, the overall RII, ranks, and SD of the causes. Table 4 extracts the five most important causes of change orders based on the opinions of the three parties.

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Table 3. Ranking of Change Order Causes

Cause	Client respondents		Consultant respondents		Contractor respondents		Overall respondents		
	RII	Rank	RII	Rank	RII	Rank	RII	Rank	SD
Owner instructs additional works	70.59	1	64.29	1	68.33	1	67.91	1	3.19
Owner instructs modification to design	65.88	2	64.29	3	63.33	8	64.65	2	1.29
Nonavailability of construction manuals and procedures for project construction in Oman	61.18	9	74.29	2	51.67	20	62.79	3	11.36
Nonavailability of engineering licensing for engineers in Oman to maintain the quality of consultancy services	62.35	6	63.33	5	60.00	14	61.95	4	1.71
Poor communication between relevant governmental units and the owner	57.65	13	64.29	4	65.00	6	61.86	5	4.05
Nonavailability of overall project planning	61.18	7	58.67	11	63.33	9	60.91	6	2.34
Unrealistic design periods	52.94	21	61.54	7	70.00	3	60.48	7	8.53
Unrealistic construction schedule	60.00	10	58.57	12	61.67	11	60.00	8	1.55
Owner fails to make decisions or review documents at the right time	54.12	19	60.00	10	65.00	5	59.07	9	5.45
Low consultancy fee or less experienced designers	58.82	12	47.14	20	73.33	2	59.07	10	13.12
Nonavailability of records of similar projects in Oman	50.59	22	62.86	6	66.67	4	59.07	11	8.40
Failure by the consultant to provide adequate and clear information in the tender documents	56.47	15	61.43	8	58.33	15	58.60	12	2.50
Natural growth of the project was not anticipated at the design stage	65.88	3	48.57	19	60.00	12	58.60	13	8.80
Owner's needs during the design stage are unclear or not well-defined	54.12	18	60.00	9	61.67	10	58.14	14	3.97
The contractor uses the gray areas in general conditions and request variations to the contract	61.18	8	50.77	17	60.00	13	57.62	15	5.70
Design errors	63.53	4	47.14	21	58.33	16	56.74	16	8.37
The design and construction criteria are outdated and do not suit the present construction technology	60.00	11	57.14	13	50.00	21	56.28	17	5.15
The contractor misuses variations instructions	62.35	5	46.67	22	53.33	19	55.12	18	7.87
Nonavailability of qualified engineers from the owner side	56.47	14	54.29	15	47.27	23	53.33	19	4.81
Consultant not familiar with the regulations and construction permits in Oman	55.29	17	55.00	14	48.33	22	53.17	20	3.94
Unilateral decisions made by the owner without proper considerations to the contract	47.50	23	52.86	16	55.00	17	51.43	21	3.86
Consultant's supervisors do not have collective experience about construction projects in Oman	47.06	24	45.33	23	65.00	7	51.36	22	10.89
Failure by the consultant to perform design and supervision effectively	56.47	16	41.43	24	53.33	18	50.70	23	7.94
Poor project management by contractor	54.12	20	50.67	18	45.00	24	50.45	24	4.60

Table 4. Extract of the Five Most Important Causes for Change Orders

Rank	Client's respondents	Consultant's respondent	Contractor's respondents
1	Owner instructs additional works	Owner instructs additional works	Owner instructs additional works
2	Owner instructs modification to design	Nonavailability of construction manuals and procedures for project construction in Oman	Low consultancy fee or less experienced designers
3	Natural growth of the project was not anticipated at the design stage	Owner instructs modification to design	Unrealistic design periods
4	Design errors	Poor communication between relevant governmental units and the owner	Nonavailability of records of similar projects in Oman
5	The contractor misuses variations instructions	Nonavailability of engineering licensing for engineers in Oman to maintain the quality of consultancy services	Owner fails to make decisions or review documents at the right time

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Table 5. Ranking Effects of Variations

Effect	RII	Rank
Delay completion date of projects	67.91	1
Variations would result in claims and disputes	67.91	2
Cost overruns	66.98	3
Adversely affect the performance and moral of labor	60.47	4
Most contractors incur additional costs due to variations	54.88	5
Adversely affect work quality	44.19	6

Table 6. Ranking Benefiting Parties from Change Orders

Benefiting party	RII	Rank
The contractor would benefit the most variations	58.60	1
The consultant would benefit the most from variations	57.14	2
The owner would benefit the most from variations	53.95	3
None of the three parties would benefit from variations	42.79	4

It is interesting to note that all parties agreed that "owner instructs additional works" is the number 1 cause of change orders with an overall RII of 67.91 and a SD of 3.19. The "owner instruct modification to design" received the second and third ranks by the client and the consultant, respectively, while the contractor gave it number eight rank. This cause received number 2 in the overall ranking with RII of 64.65 and SD of 1.29. The small values of SD of these first causes show that there is a strong agreement among all parties that the client is a major cause of change orders. No other agreement among parties on the first five causes.

The overall ranking shows the "nonavailability of construction manuals and procedures for project construction in Oman," as the third cause with RII of 62.79 and SD of 11.36. This cause was ranked second by the consultant, ninth by the client, and twentieth by the contractor. The large value of SD shows a major disagreement among the three parties on the importance of this cause.

The SD column of Table 3 shows that there are three causes that received SD values less than 2, which indicates some convergence among the respondents' answers. These causes are:

1. Owner instructs modification to design (SD=1.29);
2. Unrealistic construction schedule (SD=1.55); and
3. Nonavailability of engineering licensing for engineers in Oman to maintain. The quality of consultancy services (SD =1.71).

As all owners' respondents were from the public sector, they criticized themselves by agreeing with the consultants and contractors in giving high importance to the first cause. The modification to design is possibly a result of frequent changes in administrations and merging and splitting of governmental agencies as well as short of experience. This is also a possible result of the cause "owner's needs during the design stage are unclear or not well-defined," in spite of less importance ranks given to this cause, especially by clients (client's RII=18, consultant's RII=9, and contractor's RII=10). The second cause with small SD reflects the fact that many contractors have less knowledge on how to schedule their projects or because of imposed total construction time frame by client in the tendering stage due to different reasons. The third cause is due to the shortage of high professional consultancy personnel in Oman.

Contrary to the above, there are high standard deviations values (SD$>$10), which indicate a definitive result of opposing views among the three parties. These include:

1. Low consultancy fee or less experienced designers (SD =13.12);
2. Nonavailability of construction manuals and procedures for project construction in Oman (SD=11.36); and
3. Consultant's supervisors do not have collective experience about construction projects in Oman (SD=10.89).

The differences in the first and third causes are obvious; contractors always blame consultants for design mistakes and unclear instructions at site, while consultants blame contractors for lack of experience and cooperation. Clients stood almost neutral in the first cause, while they were siding with the consultants in the third cause.

The second cause is ranked high by the consultants (Rank 2), while the contractors view this issue with less importance (Rank 20), leaving the clients midway in their opinions (Rank 9). All of these issues highlight the importance of reviewing the existing regulations for assuring the quality of consultancy works and the need to establish professional construction manuals.

Effects of Change Orders

Table 5 presents the overall respondents' opinions on the effects of change orders. The "delay completion date of projects" is the most important effect of variation (RII=67.91). This would be expected as changes will mostly result in revision of plans, addition of works, more time for decision making, material re-sourcing, etc. In the case of omission no delay would be expected, but due to some cost saving, the client will usually use the saving by adding works which will result in delaying the project completion.

The second important effect was found to be "variation would result in claims and disputes," with RII of 67.91. This is one of the major effects, especially in developing countries, as many of the variations are not well-studied and lead to confusion and disruption, which results in claims and disputes, particularly in the case of introducing new materials or work activities that were not in the original contract. Surprisingly, this effect preceded the cost overrun although with a small difference.

Attention should be given to the least important factor "adversely affect work quality." Practically, the work-rework and delay of projects disturb the plans of the client and the contractor and put both parties under extreme pressure to complete the work. The client needs to utilize the facilities. The contractor faces problems in his future works, may not bid for new projects, and may be forced to delay other projects due to shortages in manpower and equipment that are being delayed in this project. This situation leads to the work being carried out in a hasty fashion with a low quality, especially during the finishing stage. However, few people would admit this and quality control measures are usually not strictly followed.

Benefiting Parties of Change Orders

According to the ranking in Table 6, the first party that benefits from variations is the contractor (RII=58.6), the second benefiting party is the consultant (RII=57.14), and the least benefiting party is the client (RII=53.95). The study also shows that only few people believe that no one is benefiting from change orders (RII=42.79). This means that somebody is benefiting from change orders. In the writers' opinion, all parties benefit from change orders. The contractor benefits because of money earned

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Table 7. Ranking Remedies for Change Orders

Remedies	RII	Rank
Registration of the consultant company should be reviewed to reflect its technical capabilities	77.21	1
A standard document should be developed to establish the stages/steps from the start of the project until completion and close out	72.093	2
A common learning database system should be shared among all governmental units	72.093	2
A specialized quantity surveyor/cost controller and project manager should be assigned to large construction projects	71.16	4
No design engineer shall be allowed to practice without having a professional license	70.23	5
Permanent standards shall cover all construction regulations and permits required for construction projects in Oman	68.37	6
The general conditions should be reviewed and updated	67.91	7
A construction procedure manual should be established and implemented	66.98	8

due to increase of works including unit rates, time extension, variation in quantities, etc. without competition from other contractors. The consultant benefits because of guaranteed payment for time extension and design modifications. The client benefits because he/she ultimately receives the project with less problems after corrections/modifications. Contrary to the results, it is also the writers' belief that the consultant is the one who is benefiting the most. This is so because of the low level of risk and the guaranteed fee payments in most cases. This belief was strengthened by the results presented in Table 4, where among the most important five factors causing change orders it is only one (Rank 4) is directly related to the consultant. This indicates that most of change orders are not consultant related. Therefore, the consultant will be paid for both time extensions and design modifications. Even in the case of penalizing the contractor for delays, the payment for the consultant will be guaranteed.

Suggested Remedies

According to Table 7, the most important remedy was the "registration of the consultant company should be reviewed to reflect its technical capabilities" (RII=77.21). Unlike the two most important causes of change orders "owner instructs additional works" and the "owner instructs modification to design," which are related to the client, this remedy is directed toward the consultant. This suggests that there is a close link between the qualification of the consultant and the change orders caused by the client. This is probably true because the client may not receive proper advice from the consultant during the feasibility study or during preliminary design, which leads to changes during detail design and construction. These changes are counted on the client although instigated by less qualified consultants. This finding can be explained when knowing that more than 90% of the technical staff of the consulting offices are expatriates and know little about the system in Oman [Seminar on Omanization (Sultan Qaboos Camp 2005)]. Further, recent rise in oil prices encouraged the government to offer more projects for construction, which led to contractors being overloaded by the number of projects with a shortage of qualified staff, especially engineers. This adversely affected the contractor's time scheduling of works and forced clients to accept lower quality finishing, especially if the project is delayed by the client.

The second and third most important remedies were that "a common learning data base system should be shared among all governmental units" and "a standard document should be developed to establish the stages/steps from the start of the project till completion and close out." These two remedies received the same values of importance (RII=72.1). Again these remedies are not directly asking the client as individual for improvement. Rather, they are directed toward the whole system. This shows that in some cases, change orders causes are beyond the control of the clients or the consultants. Rather they require regulations at the national level. This shows the importance of establishing and implementing standard manuals for design and construction, as well as building a national database system for soil and infrastructure services.

Table 8. Change Order Causes' Comparison between Oman and Malaysia

Rank	Cause (Oman)	Cause (Malaysia)
1	Owner instructs additional works	Improper planning by contractor
2	Owner instructs modification to design	Site management by contractor
3	Nonavailability of construction manuals and procedures for project construction in Oman	In adequate contractor experience
4	Nonavailability of engineering licensing for engineers in Oman to maintain the quality of consultancy services	Finance and payment of completed works
5	Poor communication between relevant governmental units and the owner	Subcontractors

Comparison with Previous Results

Tables 8 and 9 show comparison of causes and effects of change orders between the results found in this research and those found in Malaysia (Sambasivan and Soon 2007).

It is clear that the first two reasons in Oman are owner related, while the first three reasons in Malaysia are contractor related. This shows that higher attention should be given to projects during feasibility and design stages by clients in Oman. Problems highlighted in Oman are different from those in Malaysia due to experience differences in construction industry. Wu et al. (2005) found similar results to those of Oman.

Table 9. Change Order Effects' Comparison between Oman and Malaysia

Rank	Effect (Oman)	Effect (Malaysia)
1	Delay completion date of projects	Time overrun
2	Variations would result in claims and disputes	Cost overrun
3	Cost overruns	Disputes
4	Adversely affect the performance and moral of labor	Arbitration
5	Most contractors incur additional costs due to variations	Litigation
6	Adversely affect work quality	—

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Table 9 shows similarity of effects of change orders in both countries with slight deviation in the cost overrun importance. Similar result of time overrun was found by Kaming et al. (1997).

Conclusions and Recommendations

From this study, it was determined that the main causes of change orders are those which are related to the client followed by lack of national information and databases about the soil conditions and services. The variations resulted in delays, disputes, and cost overruns. Although the study indicated that the contractor is benefiting the most from change orders followed by the consultant and then the client, it is the writers' opinion that the most benefiting party is the consultant due to low level of risk and guaranteed payment. This is so because most of causes of change orders were not consultant related.

The following remedial steps are recommended to be followed in order to improve the management of construction projects in Oman:

1. A standard manual with a check list for design of projects should be developed to regulate all stages/steps including feasibility study, design, tendering, tender evaluations, and project awarding. This document should be implemented by a specialized governmental unit;
2. A specialized national technical unit should be established to study and evaluate overall construction practices in Oman; to establish a construction procedure manual; and to follow-up on its implementation;
3. A national database system about soil, underground services and weather conditions should be developed and made available for all concerned parties;
4. The registration of consulting companies and contractors should be reviewed from time to time to ensure the competence of their present technical and financial capabilities;
5. The client should prepare a well-defined brief document about his/her needs before entering the design stage. This can be done either by carrying out a feasibility study or circulating a questionnaire to the end users of the project and also conduct enough deliberation about the project's final intended use;
6. The client should hire well-experienced technical staff members that can advise and help the top authority in decision making on a timely manner; and
7. Unlike what happened during the sudden rise in oil prices, the government should plan the projects in a fashion that does not lead to the contractors being overloaded by the number of projects with a shortage of qualified staff, especially engineers, which adversely affect the quality and time scheduling of works.

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