

AUTOMATIC REAL-TIME MONITORING SYSTEM (ARMS) - A ROBOTIC SOLUTION TO *SLOPE MONITORING*



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Abstract

In case of natural disasters arising from landslides, the Survey Division (SD) of Civil Engineering Department is responsible for collecting topographic details and monitoring the susceptible slope movement. When carrying out a survey in these dangerous areas, staff safety is no doubt the primary concern. Timely and reliable survey results are equally important for engineers to make prompt decisions for mitigation actions. With no doubt, the long and repetitive characteristics of monitoring observations make it a resource demanding exercise to give continuous monitoring results.

To address the problems, SD has developed an Automatic Real-time Monitoring System (ARMS) to cater for continuous monitoring when severe landslide happens. The system comprises a motorized automatic total station, which is linked up to the office control unit by telephone line or wireless GSM network. With the ARMS, real-time situation of a dangerous slope can be monitored round-the-clock remotely with minimum staff resources.

Background

In August 1999, "SAM" - one of the most powerful typhoons in the past 70 years swept Hong Kong and brought heavy rainfall that caused many severe slope failures. Over seven hundred residents of Shek Kip Mei Estate were threatened by a 50m high 80m wide slow-moving slope (Plate 2) situated just 5m back from their homes. Local residents reported that boulders slipped from the slope, knocked down a fence and numerous long cracks (Plate 1) appeared on the slope surface where water and sand debris was coming out. Preliminary inspection revealed that the subject slope was potentially hazardous but more detailed information on the slope movement was required to determine whether to exercise emergency evacuation. SD was called upon to monitor the slope and provide timely results to the engineering counterparts.



Plate 1: Cracks on failed slope

Owing to the urgency of the task, SD mobilized itself to deploy three parties, at the peak period, to take observations at daytime and process survey results in roster terms. However, only three epochs a day, at maximum, were taken and the exercise eventually lasted for three months. This arrangement was extremely resource demanding, yet the outcome was less than satisfactory. To monitor the slope movement, officers needed to expose themselves in the hazardous environment for over an hour in field and then another few hours to process the raw data before delivering the results to the engineers. In an emergency situation, a several hours' responding time was absolutely too long in that we might have missed the opportunity to take urgent mitigation actions. Moreover, the landslide would also not confine its movement only at daytime when manual observation was possible.



Plate 2: Shek Kip Mei Landslide (August 1999)

From the experience of the Shek Kip Mei monitoring exercise, SD reckoned there was a genuine need to develop a versatile monitoring system which is capable to:

- set up easily
- control remotely
- run automatically
- increase the observation frequency
- operate round-the-clock, and
- deliver the survey results instantly

System Overview

To achieve the objectives, SD developed the ARMs to trigger early alarm when the target slope's movement exceeds the threshold magnitude or trend. The system comprised a field unit and an office control unit (Fig. 1) which were both the integrated products of the in-house developed program and readily available software/hardware (Table 1). In the field unit, the Leica TCA 1800/2003 motorized total station with Automatic Target Recognition (ATR) function took measurements to the target points and the field notebook performed field data reduction. With the aid of the Win98 Scheduler and PCAnywhere software, the data files were automatically transmitted at pre-defined intervals, via telephone line or wireless GSM network, back to the office control unit for graphical presentation of monitoring results.

Functionality Highlights

Telephone/Wireless communication link



Fig. 1: Field and Office Unit

Activity	Major Hardware / Software involved
Field Data Capture	<ul style="list-style-type: none"> * Leica TCA 1800/2003 * Portable Note-book computer (PIII or above) * In-house developed ARMs program
Field Data Reduction	<ul style="list-style-type: none"> * ARMs program
Auto wireless data communication	<ul style="list-style-type: none"> * Nokia Cardphone 2.0 (Transfer rate: 14.4Kbps) * Symantec PCAnywhere version 9.2 * Window 98 Scheduler
Graphical result presentation	<ul style="list-style-type: none"> * Desktop PIII computer with Win98 or above * Excel 97 or above * AUTO-MOTION Excel file with built-in macro
Instrument Status viewing & remote control of Instrument	<ul style="list-style-type: none"> * Symantec PCAnywhere * ARMs program

Table 1: ARMs System Overview

To cater for the specific requirements in slope monitoring, a number of special functions were developed to allow users to design their own observation schemes. The following paragraphs will briefly describe some of the ARMs functionality:

1. User defined monitoring schedule

Once the initial bearing orientation and the ATR target points learning session on the total station are completed, users can proceed to define the monitoring schedule, i.e. to set the start and end date/time; the frequency of the monitoring exercise; the number of measurements taken to each monitoring point per observation cycle and

the error handling routines. If a particular target is temporarily blocked by obstacles during observation, there is an available option to re-measure that particular point again after the preset time delay (Fig. 2).



Fig. 2: Monitoring Schedule

2. Automatic field data transfer

The field unit is normally placed close to the dangerous landslide area. For safety reasons and to obtain the first hand slope movement information, the field data will be transmitted back to the office control unit immediately. With the aid of Win98 Scheduler and PCAnywhere software, the field data will be synchronized as a back up in the office control unit via the telephone line or wireless GSM communication network automatically at user-defined intervals (Fig. 3).



Fig. 3: Field Data Transfer

3. User defined target searching range

When taking measurements of two or more prisms which are very close to each other (e.g. along a crack or joint), the ATR mode of Leica TCA 1800/2003 might not be functioning, as there appear multiple prisms in the field of view (FOV). To tackle the problem, users may select “Small FOV” for that particular pointing by narrowing down the beam width from the default 0.5gon to 0.15gon. As a rough guideline, small FOV should be applied when two prisms are less than 0.8m apart at a distance of 100m from the control station (Fig. 4).

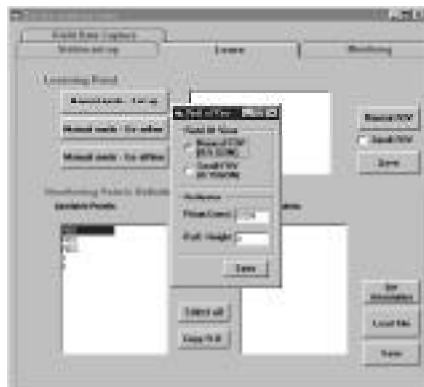


Fig. 4: Field of View

4. Remote operation and Station status check

ARMs was designed for stand-alone operation in remote areas where there are no power supply and telephone service. Once started up, it can be left unattended in normal circumstances. However, there are information about the field unit like the battery level; inclination data and the error log file which are very useful to help us understand the current status of the system. The PCAnywhere software enables the host computer (field unit) screen to be emulated on the remote computer (office unit) such that apparent control can be exercised over the field unit (Fig. 5).



Fig. 5: Remote Operation

5. Alert threshold setting

Any movement of the slope recorded in each epoch will be automatically transferred back from the field unit to the office unit. The movement, represented by the delta changes as compared to the initial values will then be used to update the settlement graph in dx, dy and dz directions. When the pre-set alert value is exceeded, a message description of the corresponding monitoring points and a continuous beep sound will be launched (Fig. 6). The warning message containing the event time; settlement values; and point identity will also be recorded in the error log file for future reference.



Fig. 6: Alert Threshold

6. Quick installation

The emergency situation during landslide requires a quick installation and set up procedures. Normally a rigid parapet wall on a building roof can serve as an ideal place for installing the ARMs field unit. The total station clamped on the pillar plate can rest on a force-centering bar permanently fixed on the parapet wall. The tailored design bell-shaped protective shell (Fig. 7) made of stainless steel also provides a certain degree of protection to the total station against burglary. An experienced user can set up the whole field unit in an hour's time.

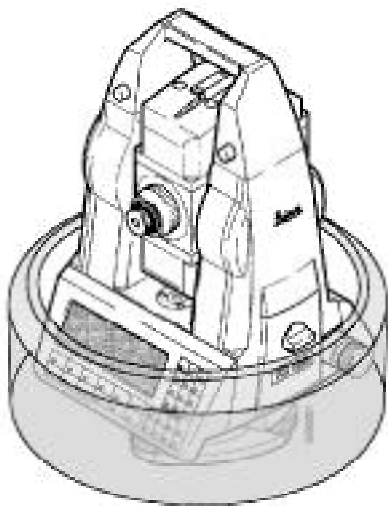


Fig. 7: Protective Shell

Conclusions

The whole ARMs set up (Plate 3) are an integration of the in-house developed program, readily available software and hardware. The additional cost to assemble the system is minimal as the most major components come from existing resources.


In order to critically examine the capability of the system, a 48 hours non-stop rigorous field test was conducted early this year to evaluate the system functions; wireless communication network and the battery life. The test result was encouraging and it proved that the system was reliable in all respects.



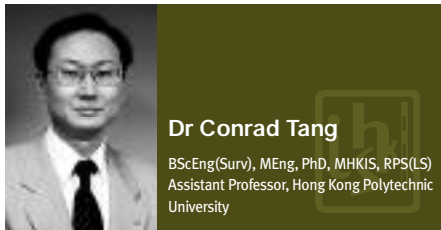
Plate 3: ARMs in operation

Nevertheless, there were areas where further enhancement could be made in future. For instance, to study the feasibility of connecting different sensors such as GPS, geotechnical and meteorological equipment on ARMs to improve the system reliability. Besides, to upgrade the wireless data transmission speed to support better performance of the video camera technology such that the real-time landslide situation could be viewed on screen remotely in conjunction with the monitoring data.

Acknowledgement

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Legal sanction of land boundary in the *Titles Registration Bill*



The Land Titles Bill gives a feeling of reluctance in handling land boundary clauses. It tries first to disclaim any responsibility in a registered survey plan, and then further limits the registered survey plan to basically recent land grants. There are not many improvements as compared to current Deed Registration System as far as land boundaries are concerned.

It has been difficult enough, as explained by the Land Registrar in the Land Titles Bill Forum held in HKIS's conference room last month, that the subject bill has been bothered and even bogged down by many titles related issues like period of conversion, indemnity and overriding interests. The Land Registry is thus very cautious to take land boundary rights on board the new registration law, where land boundary issues have long been labeled as problematic in Hong Kong.


According to HKIS's views, the Administration would only provide guarantee of ownership but no "guarantee" of boundary. In fact, there is no absolute guarantee of boundary anywhere in the world. Specifically, no one titles jurisdiction would render monetary compensation on errors of a title plan. Instead, the compensation to the error would be absorbed by the professional indemnity insurance of the licensed land surveyors. Therefore, we should urge the Administration to provide a means to properly register a lot boundary, and the 'guarantee' issue should be dealt with in our land survey law. By

the mere act of implementing a legal sanction of land boundary, it solves half of the land boundary problems in Hong Kong, whereas the remaining half is the upgrading of all existing land boundary records.

Strictly speaking, we need one major land boundary clause in the Land Titles Bill that the registration of a title plan is subjected to the satisfaction of the Land Survey Authority. By doing that, the Hong Kong SAR Government then establishes a mechanism of legal boundary. The registered Land Boundary Plan is a prima facie land boundary evidence that could be readily used for any land administration or development activities.

The other administrative and technical details should be handled by the subsequent amendments of the Land Survey Ordinance. The necessary amendments would include:

- ▶ Voluntary application for all land parcels including sections, Old Schedule Lots and New Grants;
- ▶ Title plan is prepared by an Authorised Land Surveyor so that the standard & specification could be managed under the Land Survey ordinance; and,
- ▶ Subsequent setting up of a central survey record system for deposited titles plans.

By establishing a way to register a title plan and leaving all restrictive and disclamatory considerations to the Land Survey Ordinance would be a practical approach to resolve the concerns of the general public and the Administration. Hong Kong will then have a new element in the security of land titles which has long existed in other developed societies. 

Upcoming Events

Date	Event	Organiser(s)	Reservation/Contact details
3 October 2003	Surveyors Lunch with Mr LEUNG Chin Man, Secretary for Housing, Planning & Lands (Housing) as Guest of Honour	HKIS	HKIS office Tel: 2526 3679 Website: www.hkis.org.hk
18 October 2003	Building Development & Practice in the 21st Century	HKIA, HKIE (Building Division & Structural Division), & HKIS	Conference Secretariat Miss Katherine Chow Tel: 2372 0480 Fax: 2372 0490 Email: kat@creativegp.com
25 October 2003	Building Surveyors Conference 2003 - Servicing our Buildings to Serve	HKIS (Building Surveying Division)	HKIS office Tel: 2526 3679 Website: www.hkis.org.hk
14 November 2003	Surveyors Annual Dinner	HKIS	HKIS office Tel: 2526 3679

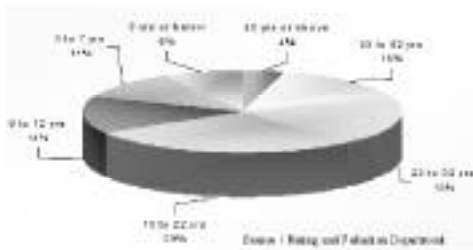
Accelerating Redevelopment



The SARS outbreak exacerbated the long-standing problem of sub-standard housing in Hong Kong. Many areas, where SARS was most rampant, were characterized by clusters of old buildings suffering from serious neglect and poor maintenance. Yet wholesale redevelopment through the years has been painfully slow, leaving many old buildings therein continuing to rot, to the detriment of their inhabitants' health.

Chart 1 below shows the age distribution of the existing housing stock. In 10 years, the number of buildings falling into the "aged" category will only increase, and the existing ones will get worse.

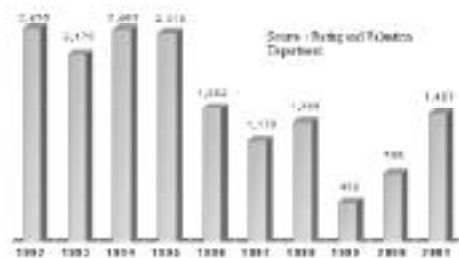
Age Distribution of Existing Housing
(% of Units)



Demolition of residential units, however, has slowed since 1996, as evidenced in Chart 2

below. The demolition rate further dropped to about 300 in 2002.

DEMOLITION OF UNITS (1992-2001)



At the present rate, it will be decades before those aged and relatively substandard buildings are gone.

Reliance on the Urban Renewal Authority (URA), a key player in comprehensive redevelopment in Hong Kong over the past 20 years, alone is clearly not enough. The most effective way, it seems, is to bring in the private sector to do the job. Yet, to speed up redevelopment, some incentives must be given, together with simplification of the procedures in resumption and redevelopment.

Piecemeal redevelopment involving one or two blocks on a small site does not solve the problem environmentally. Nor does it sound attractive to developers. A "redevelopment area" shall be designated by the government for any site having a site area of more than 400 square metres, on which 70% or more of its buildings are more than 35 years old. Many of these sites can be found in the old districts such as Tai Kok Tsui, To Kwa Wan, Wan Chai and Sai Ying Pun etc. and are even included in the URA's list of 225 redevelopment projects.

Once a “redevelopment area” is designated, a bonus plot ratio will be awarded to the development. It is suggested that a maximum bonus of 20% on the permissible plot ratio be awarded, falling in line with that permissible under Regulation 22(2) of Building (Planning) Regulations.

To prevent stockpiling, the bonus plot ratio should be accompanied by the stipulation of a building covenant, even though many of these sites are governed by virtually unrestricted old government leases. After all, the aim is environmental improvement. And as soon as possible.

The present compensation offered by the URA, based on the unit price of 7-year old flats in the same district (HK\$3,667 per square foot in Wan Chai) is prohibitively high, leaving any redevelopment scheme financially unfeasible. The outcome could only mean less redevelopment projects being undertaken.

The bonus plot ratio system will hopefully bring in private developers, thus relieving the heavy burden on the URA. With their financial resources and expertise, they can also do the job efficiently. But then, to be fully operative, some of the legal procedures should be simplified as well.


The auctioning off of the remaining 10% ownership of the undivided shares in a resumption case is a big step forward. The procedure leading to the auction, however, can be streamlined and

the timing shortened. More importantly, each case should be judged on its own merits, rather than following a rigid system.

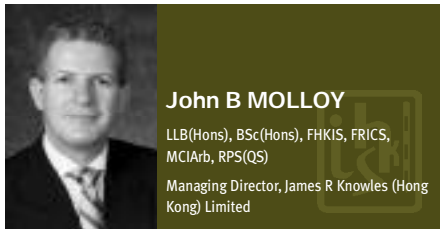
In addition, some of the resumption procedures such as relocation of inhabitants and the release of compensation should be dealt with more quickly, with a view to vacating the premises as soon as possible. The redevelopment scheme can also designate a certain percentage of units to the displaced inhabitants, reducing some of their hardship of having to start afresh elsewhere.

It is obvious that upon redevelopment a much better use of land resources shall be achieved. More open spaces can be allowed in the wake of reduced site coverage. Residents’ amenities and facilities hitherto lacking in the neighbourhood can now be accommodated in the new development.

Of course, in the current climate of a huge supply any bonus plot ratio, thus increasing supply, can be seen as contradictory to the policy of stabilizing the housing market. This is why it is suggested a monitoring system be imposed to regulate the magnitude of the bonus and the granting of it, if at all. The award of the bonus plot ratio should take into account infrastructure, utilities provision, traffic and environment of the particular locality and must be considered as part of a larger area for better planning.

No one can afford to let the living environment deteriorate, least of all after a severe epidemic. Action needs to be taken. 

Non Payment - *A Right to Suspend?*



If you ask a contractor what is the most serious breach of contract that an employer can commit he will inevitably say a failure to pay the sums due to him. When an employer fails to make payment in accordance with the terms of the contract the first reaction of the contractor will be to suspend the works until payment is made. The second and probably subsequent reaction will be to seek to terminate the contract.

Contractors are often surprised therefore to find out that at common law neither course of action is generally open to them.

The courts have traditionally made it clear that a contractor has no right to suspend the works in the event of non-payment. This has been confirmed in many cases including the leading case on this point of *Lubenham Fidelities & Investment Co Ltd v South Pembrokeshire District Council & Anor (1986) 33BLR39*.

Further, the courts generally do not treat non-payment as a repudiatory breach that gives the contractor the right to accept the employer's repudiation and treat the contract as terminated. The position does change however if the non payment is continuing over a long period of time, and in such situation the courts will accept this as being a repudiatory breach. But each case has to be examined on its merits to see the seriousness of the breach and its effect upon the continued performance of the contract.

The difficulties faced by a contractor to seek remedies at common law in the event of non payment have led to the position where most major standard forms of contract include express terms that permit the contractor to determine the contract in the event of non payment by the employer that continues for a defined period of time.

For example Clause 88(1) of the Hong Kong Government Conditions of Contract provides:

"In the event of the Employer failing to pay to the Contractor any sum certified in accordance with Clause 79 within 28 days after the same shall have become due under the provisions of the Contract the Contractor may give 14 days' notice in writing to the Employer to make payment of the sum due... In the event of failure by the Employer to make such payment within such 14 day notice period, the Contractor shall be entitled to terminate the Contract."

Whilst these provisions are satisfactory in the most serious of cases they are nonetheless a last resort remedy for the contractor who may be very reluctant to terminate the contract.

In reality giving the contractor the right to suspend the works during periods of non payment may be a far more pragmatic and sensible option, but very few standard forms of contract (save for FIDIC forms) give such right.

It was for this reason that the United Kingdom introduced the right to suspend works in the event of non payment into Section 112 of the Housing Grants, Construction and Regeneration Act 1996 ("the Construction Act").

Of course the Construction Act does not apply in Hong Kong and so with the common law traditionally not permitting suspension the only remedy left for a contractor in the event of non payment by an employer is termination either under an express term in the contract or at common law if the non payment is a continuing failure.

But the recent United Kingdom case of *C J Elvin Building Services v Peter and Alexa Noble* has thrown the traditional position of the courts regarding the lack of a right to suspend into question.

Elvin were engaged in late 2000 as the main contractor to carry out renovation work at Stortford Lodge, which was the home of Mr and Mrs Noble. As this was a contract related to the renovation of a domestic property the Construction Act did not apply.

The works commenced in November 2000 but Mr and Mrs Noble were disappointed by the progress and by a number of works they considered defective. They also briefly ran into some financial difficulties, although these were soon resolved.

However, due to a combination of all these factors the Nobles failed to make payment in respect of a number of invoices outstanding and in October 2001 the main contractor, Elvin, suspended the works.

In January 2002, Elvin issued proceedings seeking reimbursement of the sum of approximately £40,000.00. In defence Mr and Mrs Noble argued that regardless of whether or not monies were due to Elvin, Elvin had not been entitled to suspend the works, and contended that the suspension amounted to a repudiatory breach of contract by Elvin.

The first point that the court addressed was whether the Nobles owed a duty to pay all or part of the outstanding sums at the date of suspension. Whilst there were no terms in the contract concerning interim payments it was agreed that terms would be implied that the main contractor was entitled to be paid a reasonable sum and that such sum would be paid by reasonable stage installments, and indeed this had been the course of dealing between the

parties from the commencement of the contract.


On this basis and on the advice of a single joint expert appointed by the court, the judge was satisfied that there was a sum outstanding to Elvin of £40,016.52 at the date of suspension, and that this meant that the Nobles were in serious breach of contract for failing to pay a significant outstanding sum due.

The judge then considered the crucial point. Given the situation set out above, was the main contractor, Elvin, entitled to suspend the works? In his analysis he accepted that there was no question that the reason Elvin had suspended its works was due to the non-payment. He also considered that the Nobles were in repudiatory breach of contract, and in breach of what he recognized was the most important term in the contract from the main contractor's point of view.

Taking these factors into account the judge held that the main contractor was entitled to suspend the works, and that the Nobles were liable to make payment to Elvin in the sum of £40,016.52. The judge considered that the suspension was not in itself a repudiatory breach by the main contractor, and further that the Nobles could not rely upon their own repudiatory breach to justify a contention that the main contractor was itself in repudiatory breach.

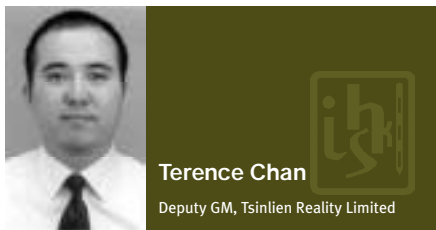
This was a most interesting case which emphasized that a failure to pay can amount to a repudiatory breach if the failure is sufficiently serious, and accepted in the circumstances of the case that the main contractor had the right to suspend its works pending payment.

However, a note of caution should be sounded before contractors in Hong Kong rush out to suspend their works where the employer fails to make payment. The above case has met with some criticism in the United Kingdom and would not of course necessarily be followed in Hong Kong.

Nonetheless, it may well be an indication that the courts are changing their view of the seriousness of an employer's failure to make payment in accordance with the terms of a construction contract. 

TEDA :

The Most Appreciated Industrial Park in China



The Tianjin Economic Technological Development Area (TEDA) is 60 kilometers east of downtown Tianjin, and has a planned area of 33 square kilometers. It has three major industrial zones: the Yat-sen scientific Industrial Park, Micro-electronic Industrial Zone and Chemical Industrial Zone.


According to a central government evaluation, TEDA ranks a national first in terms of overall economic strength. In 2000, it was among the world's top 100 fastest growth areas cited by the UN Industrial Development Organization. TEDA is currently Tianjin's and Bihai New Area's largest growth point, and also one of their most vital, up-to-date districts. Fortune magazine calls it "the most appreciated industrial park in China."

TEDA has from the very beginning been one of China's economic landmarks. According to Shen Lei, deputy director of TEDA Economic Development bureau, the secret of its success lies in having activated the high-tech industry. Danhua Bike, one of the earliest Sino-foreign joint ventures in the area, went bankrupt through its inability to adapt to market competition, the high-tech enterprises in the area all flourished.

In 2001, the electronic and communications industries realized an output value of 59.8 billion yuan, making up 57.8 percent of the area's gross industrial production. Statistics from the Ministry of Information Industrial show that in the first half of 2002, TEDA's IT manufacturing industry realized a sales volume of 32.474 billion yuan, making up 7.36 percent of the national total. It also realized profits of 4.781 billion yuan, making up 23.95 percent of the national total. It also realized a profit margin of 14.72 percent, ranking first nationwide.

TEDA regards green environment construction as its lifeline. A Japanese expert once stated that it would be impossible to grow trees on Tianjin's saline-alkaline land, but TEDA administrators have successfully planted both trees and grass in the area. Each year TEDA invests huge sums in greening, and has so formed a garden-like environment and laid foundations for an ecologically friendly city.

TEDA furthermore took the lead in obtaining ISO 14000 environment quality certification. It prohibits pollutant products of any kind, and actively deals with any pollution generated by enterprises.

The TEDA people have for years upgraded the city infrastructure and beautified the urban environment according to the motto: "modern and flourishing, pleasant and comfortable." Li Dawen, resident of Cuiheng apartments declares that TEDA has developed its industrial area and also made it into a happy home. 

Concurrent Delays - A Practical Approach - Part 2



This is the second part of a three-part article on concurrent delays - a practical approach.

Float

Who gets first call on float in a contractor's programme? Opposing views have been put forward in textbooks and technical articles. Possibly the best two articles on the subject which the writer has read were one by Vivian Ramsey and another by John Molloy.

Obviously, if the contractor does not need the float, or all of it, then the employer can have the benefit thereof.

A practical approach to float is that the contractor must have first call on it as, otherwise, programming would, or could, become contrived to eliminate float and that would not benefit a project, an employer or a contractor.

The Critical Path

When are activities on the critical path? In large projects, the critical path is not merely the string(s) of activities with zero float. Any string of activities with less than about one week's float is, in practical terms, critical due to the time risks borne by the contractor. Therefore, the critical path(s) will not just be one string of activities with zero float but there will be several strings of activities each with less than 7 days float which are also critical.

Creating Float

Where the delaying effects of an excusable event impacted upon progress it may have caused a critical path to shift or it may have

extended an extant critical path. Either way, the delay caused by a critical excusable delaying event would generate float along other non-critical strings of activities. In this case, the delaying effects of a critical excusable event rendered the original programme redundant for progressing the works but still relevant as a pre-impacted statement of intent.

For the reasons given above, the contractor would be entitled to the benefit of float created by the delaying effects of a critical excusable event on another string of activities, as, if the contract administrator had granted an extension of time as he ought to have done when the delaying effects of the critical excusable event could be identified (fully or on an interim basis), then the contractor could have re-arranged its plans and used the float. The contractor could have deferred expenditure, levelled resources or worked shorter hours.

However, what is the position if the contract administrator does not promptly grant an extension of time? Does the contractor still have to meet its original programme for all of the other strings of activities and if it does not do so, has the contractor caused culpable delay?

Additional costs incurred by a contractor in mitigating the delaying effects of an excusable event are recoverable under most forms of contract or at law but there can be no financial claim for merely complying with the original programmed intentions, i.e. the baseline scenario. A contractor who relaxed its original programmed intentions to take benefit of float generated by the delaying effects of a critical excusable event runs the risk of being accused of causing culpable delay. However, had the contract administrator granted extensions of time on time then the contractor could have benefited from the float in the other strings of activities. Therefore, if the contract administrator did not grant timely extensions, a contractor should not be expected "*to hurry up to wait*".

(i) If float was generated by the delaying effects of a critical excusable event on another string of activities, then any delaying effects of a “pacing delay” in a non-critical string of activities should not extinguish or reduce the extension of time or entitlement to reimbursement of prolongation costs caused by the delaying effects of a critical excusable event as the effects of the “pacing delay” merely consumed float and did not become a culpable delay.

(ii) Therefore, where float occurred in a programme, or was generated during construction, either an employer, or a contractor, could use such float to absorb the delaying effects of events for which they were responsible.

If the contractor was updating its programme regularly then its intentions should become apparent from the programme updates if they were properly prepared.

Delay Demonstration

With modern programming software it is possible to carry out detailed delay analysis and it is preferable if this is done as the project progresses. The time impact delay analysis using monthly windows, planned intentions and as-built data is one technique. Not only can this form of analysis be used to establish the extent of the delaying effects of events but it can also be used to establish the effects of delay mitigation measures by creating computerised simulations of what may have happened had delay mitigation measures not been taken i.e. the effects of delay mitigation measures will be apparent in the as-built programme and do not need replicating.

The accuracy of any delay analysis, whatever technique is used, is greatly influenced by the quality of information. It is usually not necessary to analyse when every nut and bolt was fitted, as the as-built database would become too unwieldy to be used efficiently. Further, at every step of the analysis there should be an empirical check. Does it look right? This should be the question asked by the analyst.

When the project is in progress, the time impact analysis technique can be used on historic data but for projecting ahead, the impacts upon planned intentions have to be forecast by developing a delay demonstration programme which simulates what is likely to occur in the

future given a particular set of circumstances in the present and the contractor’s pre-impacted intentions.

The planning, recording and commercial resources needed by the contractor, if detailed delay analysis was to be done in this manner, would be significant. Contractors do not usually establish such a resource at the start of a project (on the basis that the project may not go awry) and then spend a lot of time and effort back-tracking to prepare detailed delay analysis when things do go awry.

Most forms of contract require the contract administrator to grant extensions of time as soon as the delaying effects of an excusable event can be estimated. This means that the delaying effects of an excusable event may be ongoing when the extension(s) should be granted.

Many contracts require the contractor to issue monthly updates of its programme along with a progress report, claims notices and interim particulars. Therefore, the contract administrator should be able to grant the extension(s) of time on a monthly basis. In practice, however, this does not happen even in the most obvious cases of excusable delaying events.

Financial Claims

Even though concurrent delaying effects of culpable events should not be the cause to override the delaying effects of excusable events when extensions of time are being considered, the position is somewhat different for financial claims.

GCC Clause 63 - Hong Kong Government Form of Contract

Reimbursement of additional cost is covered by Clause 63 in the Hong Kong Government general conditions of contract for civil engineering works. For a claim to be made under this clause the contractor must have incurred expenditure, not reimbursed under any other contractual provisions, caused by disturbance to the regular progress of the works.

Under Clause 63, all that the contractor can recover is its additional costs, which can be linked to a compensable delaying event. The contractor is not entitled to profit, however, additional overheads on or off site would be recoverable subject to establishing causal nexus.

Dominant Cause

In the U.K., there is case law, which provides guidance on what is meant by the “dominant cause” approach:-

“Which cause is dominant is a question of fact, which is not solved by the mere point of order in time, but is to be decided by applying common sense standards.” (Leyland Shipping v. Norwich Union 1918)

Therefore, deciding dominance not only requires a review of criticality but also efficacy. The effects of a delaying event must have materially caused or contributed to the delay to completion. At page 212 of Keating 6th edition it states:-

“the burden of proof should require the plaintiff to establish that the loss resulted from the cause on which he relies and that he will do so if he establishes that it was the dominant cause. He should not be required additionally to disprove lesser alternative causes altogether.”

Apportionment

The alternative to the dominant cause approach is apportionment. At page 213 of Keating 6th edition it refers to the U.K. Law Commissions’ Law Reform (Contributory Negligence) Act 1945 and summarised the situation as follows:-

“where the loss or damage suffered by the plaintiff results partly from his own conduct and partly from the defendant’s breach of contract, it is correct in principle for the damages to be apportioned.”

A pacing delay subsumed by programme float would not cause loss or damage and it would not be a breach of contract. A “what if” analysis could be carried out by progressively deducting the delaying effects of each critical excusable event, one by one, until the as-built programme was shrunk back to the original contract period, or the original period plus the delaying effects of culpable events and pacing delays. However, such an analysis does not address reality and assumes that, absent the delaying effects of each critical excusable event, the contractor was helpless to mitigate delays caused by other delaying events or to avoid pacing delays. Therefore, when considering apportionment of additional expenditure incurred due to disturbance, which cost is not reimbursed under any other contractual provisions, it is not sufficient for the contract administrator to reduce the contractor’s financial claims on the grounds of concurrent culpable events, if the delays caused by those concurrent culpable events merely consumed float (they were “pacing delays”) and were avoidable.

Generally, the costs of delay mitigation are less than the costs of prolongation and, absent the delaying effects of critical events, the contractor may have been able to extinguish or mitigate the delaying effects of non-critical delays.

Additional Cost

The purpose of financial damages (in the Hong Kong Government forms of contract reimbursement of financial

damages is called the reimbursement of additional costs) is to return the contractor to the position which it would have been in, as far as money can do so, absent the breach (or for the Hong Kong Government forms of contract, the compensable events). This requires consideration of the following:-

- (i) was the event a compensable event?;
- (ii) what were the realistic effects of the event?;
- (iii) what was the efficacy of the event?;
- (iv) what could reasonably have happened had the compensable event not occurred?;
- (v) what were the true effects of the compensable event?

In the circumstances that the delaying effects of a non-compensable event were substantiated and there were preceding concurrent or simultaneous excusable and compensable delaying events, then the contractor would, or could, still be entitled to reimbursement of its prolongation costs if it could be shown that:-

- (i) float had been created by the delaying effects of an earlier compensable event on the string of activities incorporating the non-compensable event such that the delaying effects of the non-compensable event were subsumed by the float created by the delaying effects of a compensable event, therefore, the delaying effects of the non-compensable event did not delay completion but merely consumed float in the as-built scenario. This philosophy follows the dominant approach philosophy referred to in Keating 6th edition at pages 209 to 214;
- (ii) the delaying effects of the non-compensable event were not of equal efficacy to the delaying effects of a concurrent compensable event;
- (iii) the contract administrator ought to have granted extensions of time for the delaying effects of excusable events as soon as they could be identified, thereby reinstating float into the programme;
- (iv) there was no requirement for the contractor “to hurry up to wait”.

Contract administrators often opine that the contractor is not entitled to be reimbursed prolongation costs if there were culpable events, the delaying effects of which would have caused the contractor to have incurred prolongation costs absent the delaying effects of excusable and compensable events. Such opinion would be valid where the delaying effects of the culpable event could not have been mitigated and were the dominant cause of delay to completion at the time when they impacted upon progress. However, if the delaying effects of an excusable and compensable event were dominant, then the dominant cause theory provides that prolongation costs ought to be reimbursed.

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