Optimising delivery solutions for social & affordable housing, Abu Dhabi, UAE

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Al Falah Community Project – a social housing case study

With a shortfall of approximately 3.5 Million affordable homes across the Middle East and North Africa (MENA) region, the United Arab Emirates (UAE) faces a current estimated demand from 390,000 low income Emirati households (source; Gavin J (2012) - Jones Lang LaSalle). The Abu Dhabi Urban Planning Council (UPC) announced in March 2009, more than 50,000 homes will be provided over the next twenty years. Efforts were intensified in 2010 through the Emirati Family Housing Programme to create 'complete communities' of over 13,000 villas with regard to the above requirements within four years. The 'Arab Spring' and continued regional unrest places particular stress on such delivery programmes, with uprising's arguably spurred by the clear over-supply of luxury and upscale housing in many markets (amongst a multitude of other associated issues of marginalization), at the expense of the aforementioned MENA Nationals' requirements.

Projects such as the Al Falah Community development in Abu Dhabi are high profile and stringently controlled. The scheme's master-plan consists of five 'villages' presenting 4,857 villas and a range of community amenities, providing sustainable neighbourhoods serving modern needs and lifestyles whist preserving and promoting the traditional Emirati identity and preferred style of living.

This paper discusses the delivery solutions applied by El-Seif Engineering Contracting for construction of 2069No. villas across two villages of the Al Falah development; achieving low-cost and modularized delivery within an efficiently sequenced and fast-paced construction programme. Critical areas of this study are; Regional procurement, precast and pre-fabricated/ modular construction methodologies, planning, programming and progress monitoring solutions, client & stakeholder interface and handover management structures.

Considerable scope exists for the transfer of the principles and systems discussed, to future affordable and social housing projects across the region and further a-field, where unique challenges have been overcome and lessons learnt offering multiple potential extensions. Possible integration of Public-Private Partnerships for sustained growth is also particularly relevant in the current financial climate.

Keywords: Pre-cast, Modular, Pre-fabricated, Rolling-wave, Control-log.

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1. Introduction – Government & Societal demands

The Abu Dhabi Urban Planning Council (UPC) initial target is to create 'complete communities' of over 13,000 villas for future Emirati generations over the next four years; “Our objective is to answer the housing owner's aspirations by providing them with first-class communities that address their modern needs while enabling them to enjoy a lifestyle in harmony with our culture," said His Excellency Falah Al Ahbabi, General Manager UPC.

The situation in Abu Dhabi is such that tens of thousands of Emiratis have applied for government housing and remain on a waiting list up to five years long. This housing crisis has resulted in spectacular rent increases and forced many people to commute from cheaper areas, such as Buraimi in Oman. The Al Falah Community development will provide 4,857 villas of the demand with each of its five ‘villages’ arranged around a series of landscaped ‘Village and Neighbourhood Centres’. Also incorporated is a ‘Town Centre’ containing a mosque, market square and mix of local shops and offices.

2. The Solutions - Case Study - Al Falah Community Project

2.1 Regional Procurement

The El-Seif Engineering Contracting solution for Villages 2 & 3, 2069 No. villas of the Al Falah complex, critically integrated indirect stakeholders for assurance of a stable supply stream. Subcontracting work packages to locally owned and operated companies under a ‘management contracting’ procurement option, allowed for El-Seif management control to mitigate variable performance/ standards and comprehensively align deliverables to project milestones. By also subcontracting the supply and application of secondary materials on a unit-rate and contra-charging for primary materials (purchased by El-Seif and issued based on site ‘store requests’), control of material wastage was effectively transferred to the subcontractor and significantly minimized as a result.

Further subdivision of the work breakdown structure allowed for split allocation of subcontracts for certain work items which are common to all villas, although variable between villa types (Modern, Andalucian, Gulf Heritage design and 3, 4 & 5 bedroom units respectively). This provided the opportunity and flexibility for companies to compete for progressive allocation of further work packages based on a rolling production-schedule. With a similar approach applied by the project developer, a long-term client-contractor portfolio relationship is beginning to be established. This in turn allows for back-to-back relationships to be integrated into the supply chain and accordingly the partnering of critical delivery items with major subcontractors, notably for electromechanical (MEP) installations and precast concrete superstructures. In return for sustainable work flow, price may be more favourably negotiated at all levels, whilst benefits to delivery performance are realized through established relationships and familiarity with the work approaches amongst teams, driving continuous improvements and gains in efficiency.

2.2 Precast Construction - Repeatability and adaptation to re-build or remote-location settlements

Construction in the UAE cannot be compared with that in other developing economies with equally if not more critical needs on far-reduced budgets. With a far reduced scope of required facilities and amenities however, a public-private partnered, precast approach could provide equally robust, affordable, repeatable, mass accommodation, sustainably and most importantly at a rapid rate of production.

The monolithic structural design of each villa (See Figure 1, showing mechanisms for vertical and horizontal alignment and continuity once grouted), places dependence on diaphragm action between precast shear wall elements and a cast in-situ, reinforced concrete screed, to resist lateral loads from earthquake or wind actions. Pre-stressed hollow core planks transfer loads from floor areas, principally to external walls and to the corresponding edge/ ground beam forming the full raft foundation perimeter. Whilst raft and edge beam thickness and percentage reinforcement detailing will vary according to loads and sizing of superstructure elements, the above noted design is largely transferrable to sites of common ground bearing capacity and with a similarly deep groundwater table.

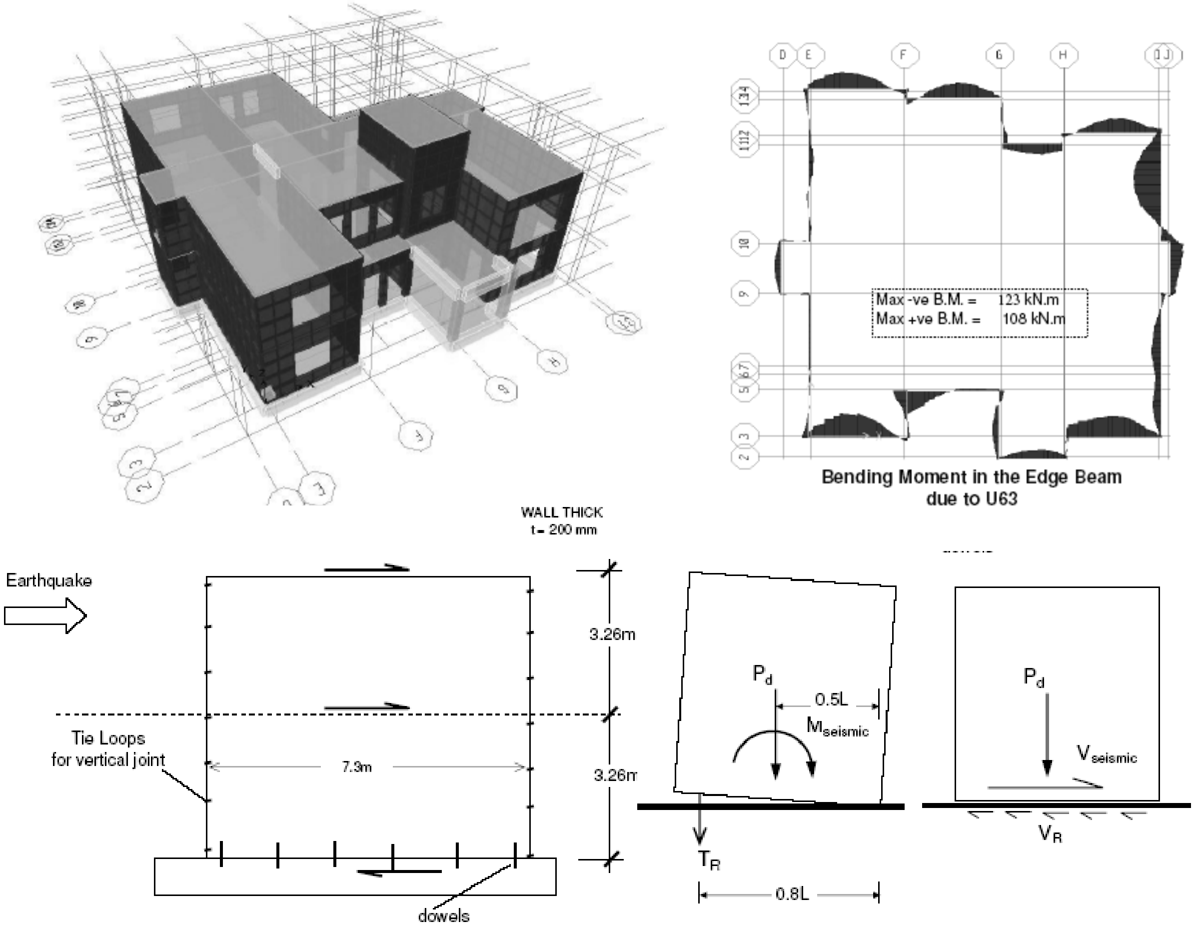

Figure 1: Structural Design System

Quality of finish is also an important factor in architectural design. For Al Falah the implemented approach involved factory casting of one precast panel face against a table-mounted formwork, with the second side surface-finished using mechanical floats, the quality of which can vary considerably. Close monitoring of the float-finished surface is necessary to mitigate significant remedial treatment/ repairs and to establish an optimal duration to spend on this activity to maintain desired quality. Requirements are clearly dependent on chosen textured or non-textured paint systems for internal and external applications accordingly. In a possible alternative to the above process, precast panels can be prepared to a rough finish to receive a site applied sand-cement render, to complete in a single operation a more consistent finish for direct application of internal paint. This is particularly relevant where conventional block and plaster partition walls have been incorporated, with inevitable interface misalignments to be overcome.

Care to ensure continuity of insulation throughout the building envelope to mitigate thermal bridging, will facilitate a potentially high-performance U-Value of a precast envelope (0.47 $W/m^2.K$ being achieved with the typical, un-modified, 200mm thick precast insulated 'sandwich' panel elements utilized on the Al Falah villas). With minimal design modifications, a typical 'Design Limit' U-Value of 0.3 $W/m^2.K$ for wall constructions may be achieved with a precast system when completed with windows and final finishes (based on UK Building Regulations Approved Document L1A, or Target average of 0.320 $W/m^2.K$ based on UAE Estidama, RE-R1). The otherwise variable quality and thermal conductivity of in-situ cast concrete (approx. 1.85 to 1.4 W/m.K) can also be more carefully controlled and enhanced when cast in a factory environment.

2.3 Concurrent infrastructure and villa construction

Concurrent infrastructure and villa construction via independent contracting organizations (Ghantoot and El-Seif respectively) presented many co-ordination conflicts, particularly where milestone completion dates are combined and shared access required at multiple phases; from concurrent villa-erection vs. deep drainage, to wearing course asphalting vs. villa finishes, snagging and handover, amongst others. A degree of trade overlap will inevitably occur to accommodate construction of main-line deep drainage, particularly where gravity-feed systems are used over long distances. Such systems commonly require wide land area for deep excavation to mitigate more expensive temporary shoring structures wherever possible.

Were phased handover not essential, a segregated construction sequence to permit continuation of infrastructure works separate from villa construction, followed by a mid-project handover would be favourable. Alternatively, introduction of sufficient lag between activities to permit concurrent working would prove more advantageous. In more remote locations this will also expedite enabling works/ construction of a means of access to a new community development from an offsite located production facility.

Undoubtedly, use of universally accessible Building Information Modelling (BIM) technology would have assisted to resolve conflicts as presented above and notably those faced at the villa boundary wall and infrastructure hard landscaping interface. Many conflicts appeared as a result of variable terrain levels and required interconnections between villa and infrastructure-contractor constructed drainage components. A ‘cloud-based’, 3D modelling service would likely facilitate more timely review of design modifications for such conflicts and perhaps eliminate many on-site if incorporated into an Early-Contractor-Involvement (ECI) design environment. To integrate infrastructure and villa contractor and critically subcontractors into this process at an early stage (promoting ownership and involvement), a real time model/ visualisation would arguably allow for streamlined and more immediate design and construction-phase planning and decision making by all stakeholders.

2.4 Use of modular components with precast superstructures

Whilst explored as a potential solution, modular bathroom units were not utilized on the Al Falah project, although they offer potentially considerable advantages and savings in just-in-time delivery, quality consistency and minimal materials wastage, where price can be more competitively negotiated considering the ‘economies of scale’. Further benefits are achievable with improved ‘returns to scale’ in the production function through technological advancement, to ultimately reduce the Long Run Average Costs (LRAC) of production, perhaps over repeat projects.

With incorporation of a pre-fabricated bathroom pod installed at the precast erection stage (See example in Figure 2), Table 1 illustrates a clear time saving of approximately 8 No. programme days per villa, when considering the contract durations and labour units modified pro rata for a typical three bedroom villa, consisting of 7 No. wet areas. A significant advantage of early completion of bathroom units is a reduced dependence of bathroom MEP final-fix installations and associated testing & commissioning inspections on ceramic tiling completion. In a direct comparison when blockwork requirements are removed, a total unit-cost per bathroom of less than 340 times local market hourly labour rates, would likely prove economical (excluding ceramic, paint and sanitary ware/ finishing items and accessories materials costs estimated at upwards of US$1000).

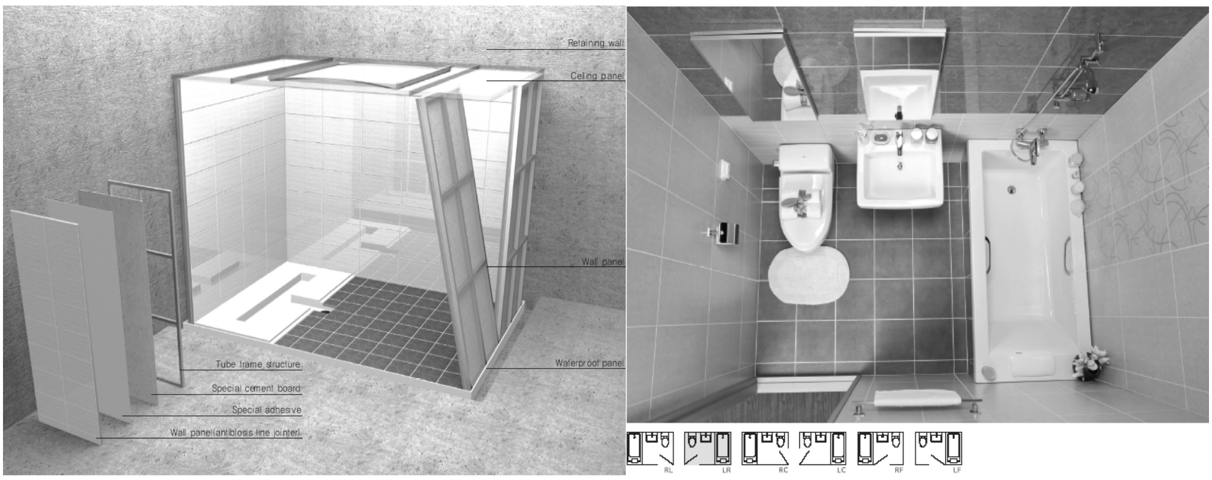

Figure 2: Potential modular bathroom system (Design type: Daelim Batos© DBR)

Table 1: Pre-fabricated 'modular' bathroom vs. in-situ construction

Item Description	In-situ construction method: Duration (Programme Days)	In-situ construction method: Labour units (Labour days)	Pre-fabricated method: Duration (Programme Days)	Pre-fabricated method: Labour units (Labour days)
Construction and plastering of blockwork partitions	0.56	8.05	-	-
Installation of bathroom pod & sanitary items	-	-	3.00	2.00
Partition wall inspection	1.00	-	-	-
Application of wet area bituminous waterproofing	1.01	0.57	-	-
Wet area waterproofing testing and inspection	1.00	-	-	-
Installation of ceramic tiling (floor and wall)	1.00	8.19	-	-
Ceramic inspection	1.00	-	-	-
Ceramic grouting	0.01	0.61	-	-
Application of internal paint	1.08	1.64	-	-
Installation of vanity frame and countertop	0.20	1.31	-	-
2nd Fix bathtub installation and plumbing	2.40	9.84	-	-
2nd Fix inspection	1.00	-	-	-
Final fix sanitary ware and accessories installation and plumbing	0.45	2.59	-	-
Final Testing & Commissioning	1.80	2.86	1.50	2.86
Total Programme Days	12.51		4.50	
Total Programme Days saving	0		8.01	
Total Labour units		35.66		4.86
Total additional Labour units		30.80		0
Total labour costs (per unit hourly labour rate)	356.55		48.60	
Budget cost - Manufacture, installation, testing & commissioning x 10% O/H & Profit, excl. Materials (per unit hourly labour rate)			338.75	

Assumptions: 1st fix activities common to both pre-fabricated and in-situ constructed methodologies. 2nd Fix inspections conducted in factory, not affecting project duration for pre-fabricated method.

NB: Potential savings through substitution of alternative materials in pre-fabricated method e.g. ceramic tile bedding, waterproofing requirements - above comparison based on like-for-like materials usage.

2.5 Construction-phase planning and programming

"The critical challenge has been to consistently produce and build five villas per day. As a leader in the UAE precast industry, Gulf Precast mobilised seven of its plants to achieve this requirement, including a mobile production facility that was directly installed and commissioned on-site".

"Precast is ideal for large villa projects, as it fosters substantial cost-savings through economy of scale and allows to significantly reduce the construction time."

“As precast elements are produced in a factory environment before being assembled on-site, all components are controlled and inspected before being transported, which allows for better quality and sustainability.” Comments from Gulf Precast CEO, Elias Seraphim, speaking to *Construction Week* magazine on the Al Falah development, at the “Precast for All” seminar in Dubai, May 2012, adding some explanation to the now forty percent share of the use of precast in concrete construction aspects of the UAE’s industry.

Precast production was optimized utilizing seven partially and fully-automated factories including a mobile production facility that was directly installed and commissioned on-site. All factories operated on three shifts including night working and concurrent electromechanical installations, largely eliminating site based 1^{st} fix activities. Conventional, site cutting, chasing and patching for electromechanical containment/ piping was no longer required (with the exception of bathroom areas as discussed above). 1^{st} fix activities were ultimately limited to floor conduit/ pipe routing connections between wall-embedded services, primarily cast into raft foundations and structural screeds for ground and first floor systems respectively.

“Fast assembly considerably limits the exposure of working at height, making precast much safer than traditional methods,” added Seraphim. Inclusion of proprietary edge protection in the precast manufacturing process can effectively mitigate the need for works at height to install fall arrest systems. Bespoke safety measures designed and implemented by El-Seif efficiently controlled precast erection operations and roof parapet protection for follow-on trades. Panel and stair-mounted edge protection was installed on completion of ground and first floor walls respectively.

A typical villa erection team of 4-5 No. workers once mobilised at a villa plot can complete erection of approximately 15 No. precast wall panels over a ten hour shift, completing a full floor installation of an average 25 No. panels in two days. Subsequent level and alignment using push-pull props, grouting, first floor beams installation, levelling, alignment and grouting, first floor hollow core floor planks and final cast-in-situ structural screed is completed over 11-15 days. All precast activities are executed by up to five independent, dedicated teams of no more than 4-5 No. workers. Work teams are accompanied by a single, 50-Tonne capacity, mobile crane, moving to three un-loading/ placement location arrangements per activity.

“The precast system, ready for paint, took from about 1,850 man-hours; the cast-in-place system ready for paint took about 6,700 man-hours….Using precast fabrications reduces labour costs by up to 25%, compared to conventional concrete.” Comments from Max Jordan of Fluor Middle East, on the Al Falah development, “Setting the Pace” – *Construction Week* magazine, July 2012.

The only significant disadvantage in the use of precast has been its effect on construction sequencing. With production distributed across multiple factory facilities, delivery timing to maintain a ‘block-by-block’ logic sequence was not possible owing to the mix of villa designs and bedroom-capacities within each block (as Figure 3 illustrates). A four week look-ahead (rolling wave plan/ programme) approach combined with daily production outputs and as-built records was critical to success.

Also essential to maintaining progress of five villas per day on average, was careful consideration and often build-up of critical-chain duration buffers. Anticipation of manpower supply problems/ shortages for the above prompted the crashing of substructure activities, allowing significant resource levelling to assist finishing works. This early decision permitted the expected, scattered precast production and erection programme to continue, given advanced completion of wider areas of raft foundation substructures.

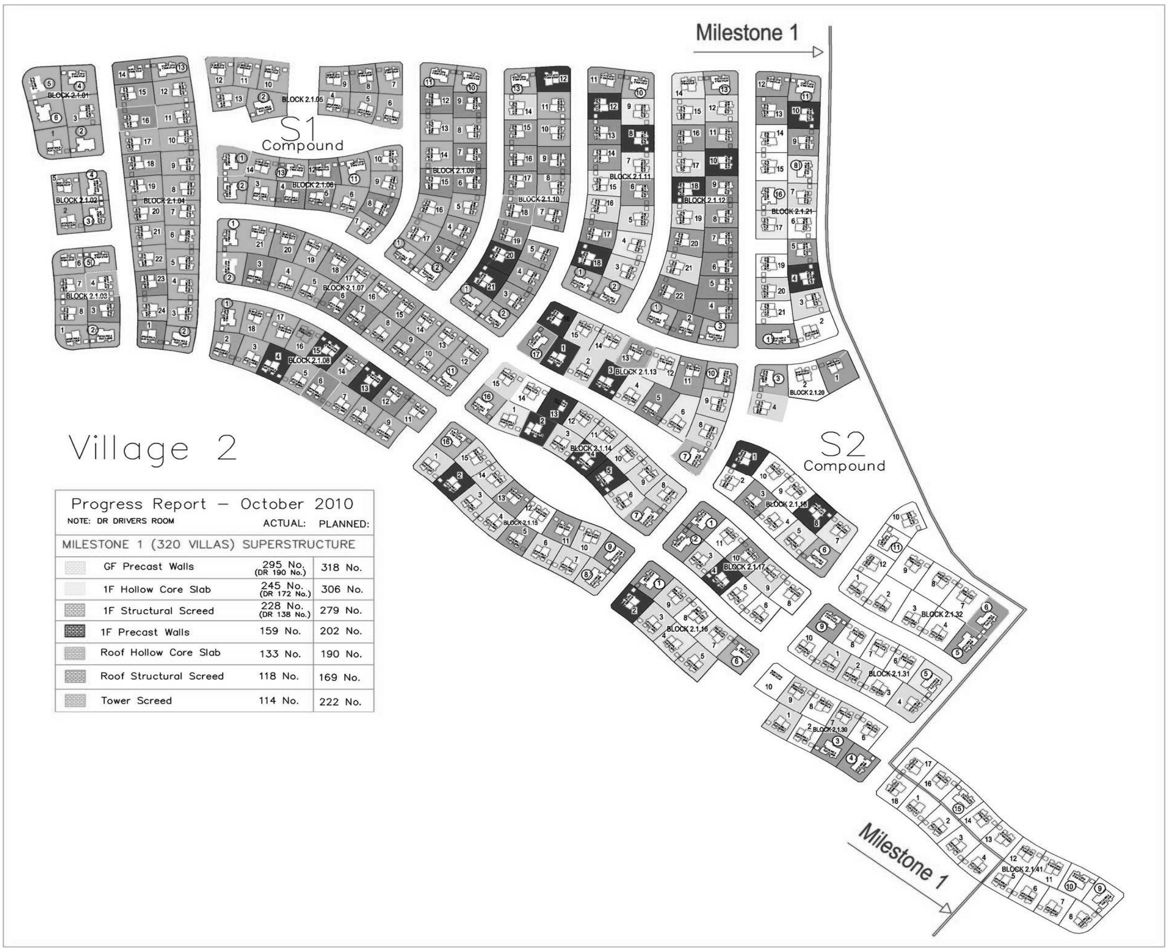

Figure 3: Superstructure progress report summary October 2010 – Plan overview of scattered precast erection sequence

2.6 Management Information Systems (MIS)

Practically, owing to the vast scale of the Al Falah project and requirements for tracking the work efforts and productivity of upwards of a six thousand man workforce, the direction of site personnel and multiple subcontractors required close structuring through a daily stop-shift meeting. Accompanying the above co-ordination meetings, a single, project-wide control log, in the form of a customised Excel spreadsheet was used for the measurement and monitoring of Schedule Variance. Following inputs of cumulative progress by section managers for substructures, superstructures and finishes works and by concerned subcontractors for MEP clearances and boundary wall erection, completed or percentage-completion achievements are accurately recorded.

The final control log (extract provided in Figure 4) may be manipulated/ filtered, but has been designed to highlight and tabulate pending and imminent priority areas for completion, in addition to a day-rate/ daily output calculation. The log is also segregated to represent the achievement of individual sections, an important inclusion on a project of this scale where daily diarised reporting is often inadequate. This provided the basis/ visual guidance for investigation and accurate reporting of unplanned events and remedial actions necessary to prevent reoccurrence across larger numbers/ wider areas of villas.

The updated control log is subsequently integrated into an Earned Value Analysis on a monthly basis and forms an essential component of the Contract Variance Unit Costing cost-control system. This system is used for monthly reporting and to proactively determine deviations from target price.

2.7 Operations management structure/ client interface

Handover and snagging disassociated from primary construction activities allowed for a strong client interface to be maintained and dedicated client-needs focused team for interrelated show-villa/ public-relations facilities, tenant orientation and client/ consultant change requests. This management of the interface with the project developer/ Project Management Consultant (PMC) and accordingly the UPC was critical to the projects' success.

AL FALAH PROJECT - WEEKLY PROGRESS RATES

	6-Jul-12		REV. 03 FINISH DATE	REQ. RATE	MILESTONE 3: VILLAS REMAINING Stage:	272	247	241	250	29-Jun-12 Village 3	29-Jun-12 Av / Day	6-Jul-12 Village 3	6-Jul-12 Av / Day
INTERNAL FINISHES	Roof Cluastra				142	-	4	38	100	648	**4.2**	671	**3.8**
	And. GRC Installation *91 / 67 / 83 / 67*		14-Aug-12	**3.2**	107	-	-	16	91	216	**0.0**	216	**0.0**
	Roof Shaft (4 Course)				307	1	2	59	245	637	**10.0**	703	**11.0**
	Roof Shaft Precast Capping 108				415	4	35	130	246	548	**7.2**	595	**7.8**
	And. Clay Roof Tiles		5-Sep-12	**3.7**	193	-	43	59	91	91	**1.7**	115	**4.0**
	Wet Area Waterproofing	Gd	2-Aug-12	**7.3**	168	-	-	-	168	803	**5.3**	842	**6.5**
		1st		**5.7**	133	-	-	-	133	652	**4.5**	680	**4.7**
		Driver	(2nd July)	**7.4**	171	-	1	2	168	799	**5.0**	839	**6.7**
	MEP Wet & Dry Area Clearance	Gd			137	-	2	-	135	830	**5.3**	873	**7.2**
		1st			108	-	2	-	106	673	**4.3**	705	**5.3**
		Driver			-	-	-	-	-	977	**0.0**	977	**0.0**
	Ceramic CRI Approval	Int	30-Sep-12	**6.6**	490	-	134	106		486	**6.2**	520	**5.7**
		Ext	30-Oct-12	**7.2**	716	-	247	175		279	**1.7**	294	**2.5**
		Driver	(30th July)	**7.1**	527	-	160	114		405	**6.0**	483	**13.0**

ACTIVITY:	REV. 03 FINISH DATE	REQ. RATE	Villa Equivalent Completed	Villa Equivalent Pending	29-Jun-12 Cum (m2)	29-Jun-12 Villa / Day	6-Jul-12 Cum (m2)	6-Jul-12 Villa / Day
Floor Ceramic (Av 392m2)	30-Sep-12	6.7	517	**493**	188615	6.71	202621	5.95
Wall Ceramic (Av 132m2)		6.5	528	**482**	64511	6.92	69724	6.58
Internal Paint (Av / Villa 1121 m2)	26-Aug-12	11.4	511	**499**	535587	2.87	572631	5.51
External Paint (Av / Villa 748 m2)	8-Sep-12	5.0	735	**275**	536905	4.06	549420	2.79

Figure 4: El-Seif Engineering Contracting, Progress Control Log extract

3. Conclusions & Recommendations

The current emphasis within the MENA region is on the construction of social not affordable housing for mid to low-income families, whilst funding remains readily available. Land prices are a particular factor in the gulf-states, forcing affordable housing schemes to remote and isolated areas that demand considerable accompanying investment in utilities and infrastructure services. State-owned land however offers a key opportunity for developers to be transferred ownership in order to sell to low-income buyers/ tenants through long-term equity and grant finance structures for individuals, at a lower cost. Revenue streams can therefore be controlled for developers, whilst rental and unit pricing may be controlled by government.

Traditional Engineering, Procurement and Construction (EPC), design-build methodologies are unlikely to meet the Gulf's rapidly expanding demand for low-income housing, where governments must look beyond one-off project procurement to establish integrated infrastructure, utilities and accommodation construction schemes and teams for sustained growth.

The advantages and repeatability of precast solutions, potentially combined with modular, pre-fabricated components can provide rapid structures, complying with the highest of quality and sustainability standards. Development of co-located production and construction sites will secure long-term delivery solutions for isolated and remote locations where planning and operations management solutions such as those developed by El-Seif Engineering Contracting on the Al Falah project, facilitate rapid deployment and maximum flexibility.

References

CW Staff (2012) “Precast success”, *Constructionweekonline.com*, 3 March 2012 (available online at http://www.constructionweekonline.com/article-15852-precast-success/1/print/ [accessed on 11/08/2012])

CW Staff (2012) “Precast takes the lead”, *Constructionweekonline.com*, 25 June 2012 (available online at http://www.constructionweekonline.com/article-17403-precast-takes-the-lead/ [accessed on 19/08/2012])

CW Staff (2012) “Setting the pace”, *Constructionweekonline.com*, 18 July 2012 (available online at http://www.constructionweekonline.com/article-17670-setting-the-pace/1/print/ [accessed on 25/08/2012])

AutoCAD®Civil3D® ”The City of Riviera Beach*”,* customer success story*,* (available online at http://usa.autodesk.com/adsk/servlet/pc/item?siteID=123112&id=16881945 [accessed on 01/09/2012])

Estidama “Pearl Villa Rating System”, PVRS U-Value calculator for credit RE-R1, (available online at http://estidama.org/pearl-rating-system-v10/pearl-villa-rating-system.aspx [accessed on 01/09/2012])

Gavin J (2012) *Private sector eyes low-cost niche,* (available online at http://www.thegulfonline.com/thegulf@tradearabia.net [accessed on 01/09/2012])