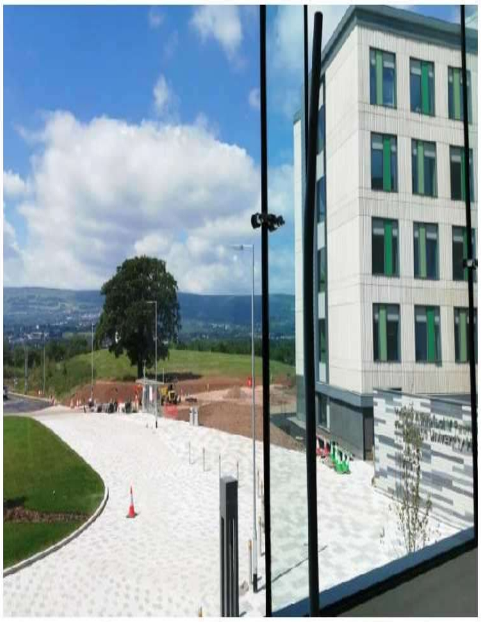
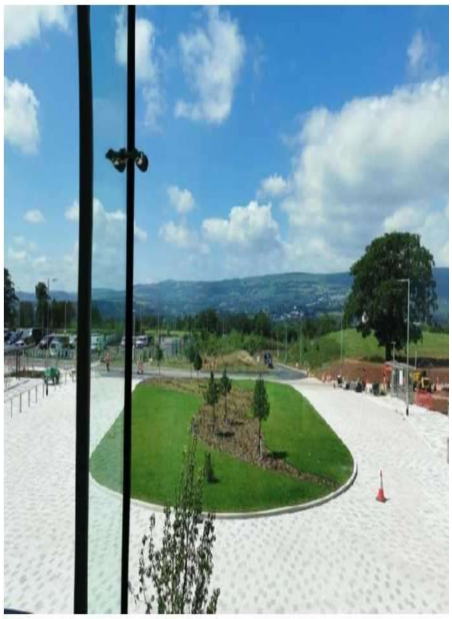
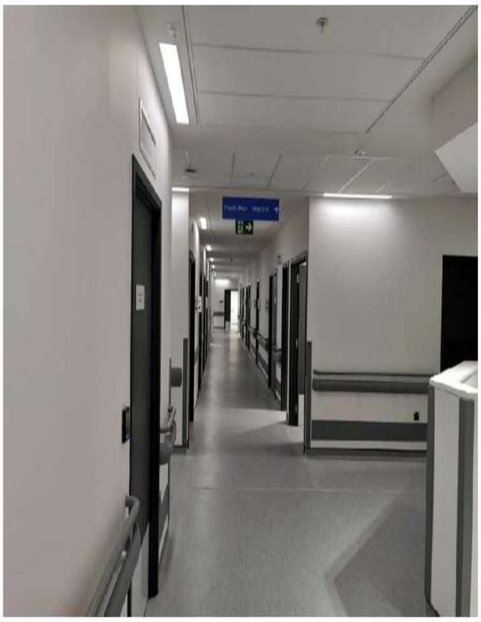
The Grange University Hospital, Llanfrechfa

The Benefits and Dis-benefits of Modern Methods of Construction

July 2021



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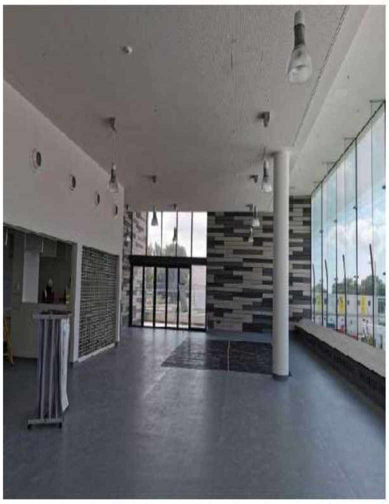


Contents

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1.0 Executive Summary

McBains (MCB) has been appointed by NHS Wales Shared Services Partnership to undertake a Case Study on the Benefits and Dis-Benefits of Modern Methods of Construction (MMC). It is important to note that Design for Manufacture and Assembly (DfMA) is Laing O'Rourke's response to Modern Methods of Construction and so for the purposes of this case study the term can be used interchangeably.

This study covers a broad range of considerations with a primary focus on time, cost, quality, flexibility, and risk, with further consideration of other factors including health and safety, supply chain engagement, whole life costs and community benefits. This case study considers each of these and provides detail and substantiation to support the case presented.

There are many benefits that have been realised in the delivery of this project utilising DfMA as the means of construction. The benefits are best summarised as (a) Reduction in programme duration with savings of 23% on The Grange University Hospital, (b) increased programme predictability, (c) improved cost predictability, (d) improved quality of components and final building asset, (e) reduced lifecycle cost (f) more robust design prior to construction (g) reduced risk (h) improved health and safety and (i) a more integrated supply chain.

Some dis-benefits are apparent and can be best captured with (a) supply chain engagement and the lack of flexibility and competition, (b) reduced flexibility for future change due to prefabricated components and, (c) lack of construction throughput maintaining a cost neutral position, (d) low level of research and innovation.

When considering the overall benefits in contrast to the dis-benefits, the benefits far outweigh the disbenefits. This can be clearly demonstrated with the final construction programme with the facility opening 3 months ahead of programme during a time of a pandemic, thus allowing the hospital to be used for COVID patients, which would not have occurred with a traditionally built healthcare facility. The cost predictability has been extremely accurate with the final project cost anticipated to be £5.778m below the approved FBC figure. The quality of the building, and the handover and commissioning process facilitating the completion of a highly successful building all substantiate the tenet that DfMA as a method of construction delivers benefits to projects.

Whilst MMC may not be in its embryonic stages of development, it still must develop further to glean the full construction benefits outlined in the Egan Report, 'Rethinking Construction' written in 1998 and the Government Construction Strategy written in 2011, which still stand as outlining the key criteria to generating improvements in the construction sector. Due to the volume of construction that is delivered using MMC, the level of research and development, competition and options is still limited. The medium to long-term goal would be to increase the volume of construction work delivered via MMC to create a more developed, flexible, and open MMC offering to the market.

2.0 Introduction

McBains (MCB) has been appointed by NHS Wales Shared Services Partnership to undertake a Case Study on the Benefits and Dis-Benefits of Modern Methods of Construction for the new SCCC at Llenfrechfa, now called The Grange University Hospital.

The Grange University Hospital is a new 560 bed hospital built on a 60-acre site, and will provide emergency and urgent care, while bringing together services provided at the Royal Gwent Hospital in Newport and Nevill Hall Hospital in Abergavenny. The Grange University Hospital serves over 600,000 people integrating 40 specialist services and includes a helipad, 13 operating theatres, a Cat 3 laboratory, two MRI suites (one as a shell), two CT suites and an education block.

An FBC Addendum was submitted by Aneurin Bevan University Hospitals Board to the Welsh Government on 14th October 2015, with approval granted in October 2016. Market testing concluded at the end of September 2017 to commence construction enabling works in October 2017.

The integration of Modern Methods of Construction (MMC) is considered to be the future of construction and should be incorporated into the design of new publicly procured buildings. MMC has become an area of increased focus in the past few years and, whilst a consideration at the concept stage of The Grange, the boundaries of MMC have been challenged and pushed in the delivery of this project.

MMC is a broad term covering a wide range of offsite manufacturing and onsite techniques, which are used as an alternative to traditional building methods of construction. Design for Manufacture and Assembly (DfMA) is Laing O'Rourke's (LOR) response to MMC and incorporates a number of offsite technologies to drive efficiencies in construction. This addresses some of the targets cited by Egan in his 1998 report 'Rethinking Construction' with focus on improved productivity, reduction in cost, reduction in construction time, predictability of programme and cost, reduction in defects and reduced accidents.

Due to the success of The Grange delivering a high-quality healthcare facility to budget and ahead of programme, attention has been drawn to the methodology of construction in contributing to project success. It is notable that the project has also won two significant awards in recent months; Construction Excellence Wales Award for Digital Construction 2020, and Offsite Project of the Year 2020 also bestowed by Constructing Excellence Wales.

This Case Study considers a broad range of factors with particular focus on the primary decision drivers of time, cost, quality, flexibility, and risk. Other important considerations are also covered such as health and safety, design control, buildability, Whole Life Costs, and supply chain engagement.

As part of the study, a number of project documents have been reviewed and analysed, these are listed at the end of this document. We also conducted interviews with key members of the project team based upon a structured questionnaire; which is included within the appendices.

3.0 Benefits and Disbenefits of MMC

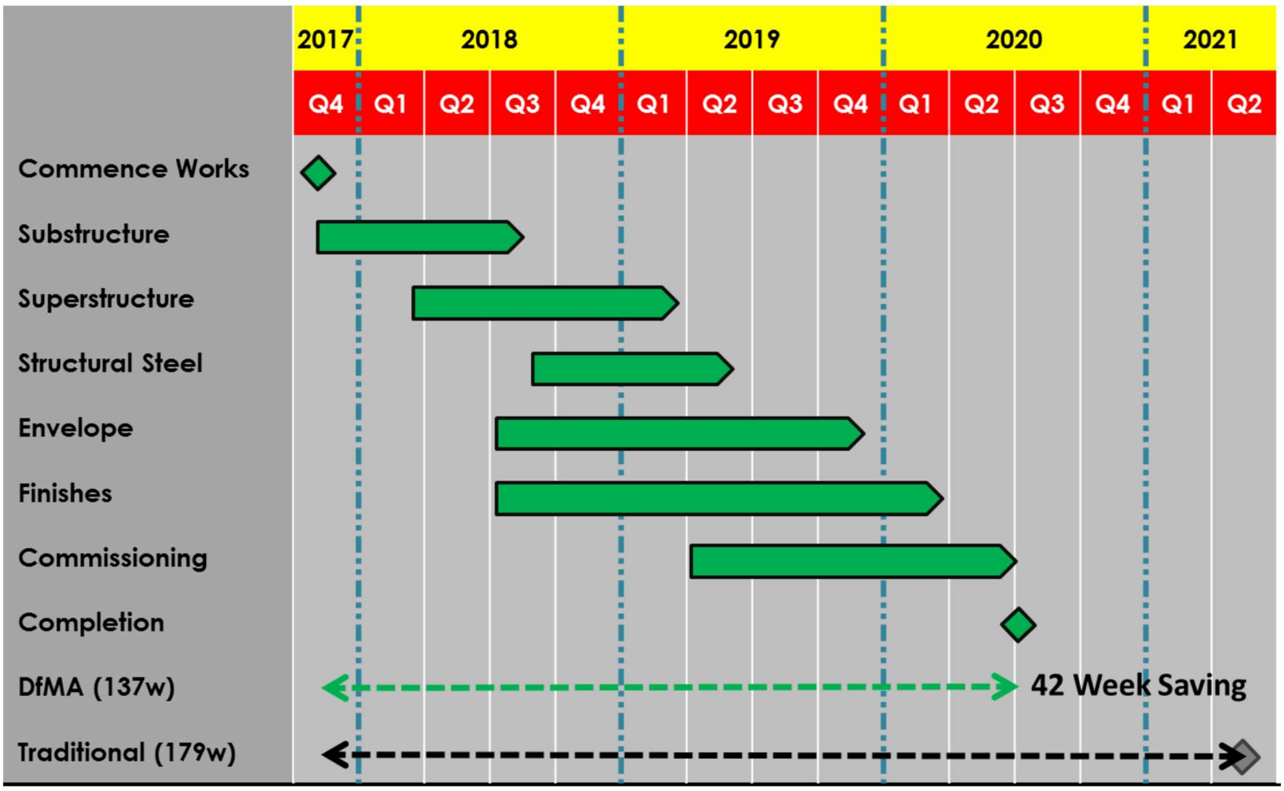
Programme

It is important to capture the full programme impact from inception to completion to establish the holistic benefits to the programme. The key programme stages considered are design, market testing and construction. It is also important to consider both the duration of the programme and the confidence with which programme can be predicted. Whilst duration of programme gleans obvious benefits, equally predictability of programme facilitates good planning generating service delivery and cost benefits.

The design programme duration remained consistent with the duration expected with a traditional design approach; however, it is important to note that the detail and coordination of the design prior to procurement and fabrication of the offsite components must be well developed. The clinical engagement process must be clear and well-established to facilitate a robust and agreed clinical sign-off at key milestones of the design process. The DfMA approach engenders a spirit of good practice pertaining to both clinical engagement and design deliverables. This improves the standard of the design prior to commencement of works on site.

The programme for market testing also remained consistent with a traditional approach. This is partly due to a number of packages following a normal procurement process, but also due to the key component elements of DfMA (Pre-cast superstructure elements and MEP) requiring integration of material, labour and plant to deliver these components. The MEP package is normally the element that falls on the critical path for market testing and this package incorporates several supply chain members and component market testing in tandem with the DfMA components.

Improvements to the construction programme have been widely publicised. The original duration of construction was established at 179 weeks with commencement in quarter 4 of 2017 and completion in quarter 2 of 2021. A DfMA programme was developed showing a programme duration of 137 weeks generating a forecast saving of 42 weeks, equating to a 23% improvement on the construction period. This is graphically represented by the LOR programme comparison provided below.



To support the proposed programme, a comparison of the Gross Internal Area completion rates per week compared to other recent healthcare projects was undertaken. This demonstrated the traditional procurement routes used for Ysbyty Aneurin Bevan and Ysbyty Ystrad Fawr, both constructed following traditional methodologies delivered 104m2 and 200m2 per week respectively. It should be noted both these were smaller in size (11,750m2 and 32,000m2 respectively). The proposed traditional programme for The Grange of 163 weeks, delivers 309m2 per week. Other notable projects delivered via DfMA range in size between 50,400m2 and 95,115m2 all delivering areas above traditional construction norms, with a range of 417m2 – 464m2 per week. This supported the view at the time of entering into contract that the proposed DfMA programme for The Grange was achievable.

The DfMA initiatives contributing to the improved programme times included the following key components:
a. Precast Columns – 8,210 on-site hours saved
b. Lattice Planks – 26,695 on-site hours saved
c. Delta Beams – 11,407 on-site hours saved
d. Hollowcore Slabs – 33,854 on-site hours saved
e. Twinwall – 42,240 on-site hours saved
f. Precast Façade panels – 68,957 on-site hours saved
g. MEP service risers – 14,162 on-site hours saved
h. MEP Horizontal Modules – 15,864 on-site hours saved
i. Prefabricated AHUs – 10,350 on-site hours saved
j. Prefabricated Plant Skids – 2,560 on-site hours saved
k. Bathroom Pods – 9,720 on-site hours saved
l. Precast Manholes – 2,800 on-site hours saved

Adopting a DfMA solution, also improved the predictability of programme. Due to offsite manufacture, programme risk is reduced, and the level of programme certainty is significantly improved. The reason for the improved predictability is three-fold, firstly the construction of the components in a controlled environment is more predictable reducing the impact of site-specific challenges, secondly, the supply chain is controlled by LOR directly for these components and as a consequence third party risk is reduced, and thirdly accountability and responsibility resides within in-house organisations facilitating control and just-in-time deliveries.

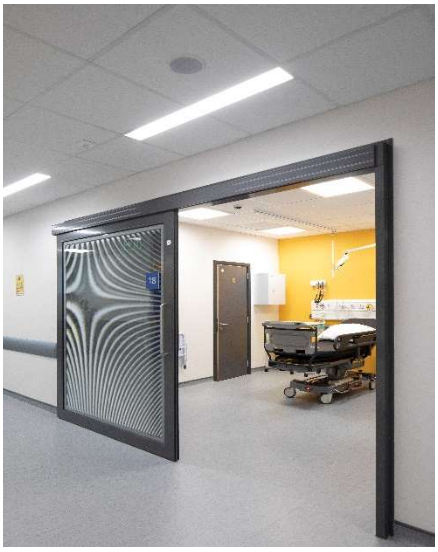
There are several benefits to having a more predicable programme. The commencement of delivery of clinical services can be accurately predicted and as such communication with staff, patients and users is quicker, cheaper, and more efficient; it also enhances the employment of high quality clinical and non-clinical staff including staff retention. Equipment delivery is more predictable generating procurement cost benefits, installation benefits and commissioning benefits. There is an avoidance of abortive visits for delivery, training, approval, witnessing, and commissioning. Reduced storage requirements on and offsite, and improved efficiency of logistics, reducing staff time and cost. Finally, the improved sequencing and predictability of installations improves quality of the final building as all works are delivered in the planned and correct sequence.

Cost

The preliminaries were reviewed in conjunction with the proposed construction programme, which generated an overall cost of £20.9m. This equated to 12.63% of the works cost total. The fixed cost component of the preliminaries was 18.4% and the time related element 81.6% with a time related cost per week of £113,887. The percentage allowance for preliminaries is at the low end of the range of benchmark norms for a project of this size, nature, and complexity, with the range usually being between 12.5% and 15%. Based upon the programme duration for a traditional approach of 179 weeks and the DfMA approach of 137 weeks, this generates a saving of £4,783,254 for time related preliminaries, based upon the 42-week DfMA programme improvement.

A clear open book package procurement strategy was established with an approach to the procurement of each package, agreement of the timing, release and sharing of supply chain tender information, validation of tender returns, involvement with interviews, validation of scope gaps, interface analysis and agreement to the package analysis and recommendation. The process included the normalisation of tenders and demonstration of value for money.

When analysing the cost of each package, we would suggest that there is a slight premium paid in nominal terms for some of the DfMA sourced works, when compared to traditionally designed, procured and built solutions. There is a slight uplift in the cost for structural facades, slab systems, and the Twinwall solution. The cost of the labour, plant and materials are aligned to market norms; however, there is a slight uplift in baseline cost for research, development and the factory set up costs, which are reflected in the overhead element of the cost profile. This is partly due to the construction industry as a whole not fully embracing the MMC agenda to date and the overall construction throughput for new buildings still using traditional construction approaches. The vision would be for a greater throughput to be generated via MMC, which would provide cost benefit in the medium to long-term.



Whilst there may be a slight premium to pay on some of the packages, the overall package value is marginally higher than a traditionally built project, the two cost components that are reduced are preliminaries and the risk profile. The risk profile to which a contractor is exposed to on traditional construction for a project of this size, nature and complexity is 3% - 4%, which is included within the agreed GMP. Due to the reduced risk profile the level of risk via a DfMA construction methodology is reduced to around 2.7%, generating a benefit not only on cost but also an improved cost predictability. There are inherent benefits to cost predictability, as this facilitates accurate cost projections for cash flow purposes, it also facilitates undertaking earned value analysis to establish if the project spend is in line with the anticipated figures, which can determine where there are discrepancies if the project is ahead or behind programme.

As a consequence of the balance between package procurement prices, preliminaries costs and a reduced risk profile, the overall cost position for DfMA is cost neutral. Whilst there is not a reduction in cost for the overall project, there is an improvement to cost predictability, facilitating benefits in cash flow, funding and revenue generation for the new facility once complete and open.

Quality

Owing to the factory conditions in which DfMA components are manufactured, as opposed to the typical conditions of construction sites, which are significantly affected by the weather and other factors, the quality levels of modular solutions are easier to control and generate a benefit to the quality and reliability of the finished product.

This has the further benefit of reducing inherent defects within the building components and, as such, also engendering a 'zero defect' philosophy on the project from its inception.

The challenge associated with DfMA is that the design solution will need to be progressed to a detailed standard before fabrication of components commences. Whilst this will be a challenge and may be seen as a dis-benefit, it encourages good design practice in the following ways:

a. Progression of design to an enhanced level of detail
b. Improved coordination of design activities between architectural, MEP and structures
c. A more robust and detailed clinical engagement strategy to ensure full sign-off

The benefit gleaned is a more robust, detailed, coordinated, and signed off design prior to fabrication and progression of works on site. This reduces risk but also improves the quality of the final building as the fabricated units are built in a controlled environment. Completing the components in factory conditions also facilitates testing of the components and improves the tolerances of the products, resulting in a more reliable and robust end product.

Production of DfMA components in factory environments means that the components are inherently more robust, thus they are able to resist damage both during the construction and throughout the lifecycle of the facility.

The fire integrity and fire rating performance of components can be fully tested in the factory and achieves a high level of performance; changes to insulation as a result of industry concerns after Grenfell, for example, have been incorporated into the design solution for the external walls. One key benefit of DfMA and offsite manufacture is the design and incorporation of service penetrations within the manufactured panels; this again requires progression and coordination of design but reduces risk of compromising the fire strategy and duplication of work during installation on site. There is also an improved air tightness achieved with manufacturing components offsite, which will have energy saving benefits.

One of the often-cited challenges with traditional construction methods is the requirement for on-site adaptations, borne out of lack of design detail, and coordination not always being progressed to a satisfactory level. DfMA does not allow for design detail and coordination not be fully progressed and consequently, onsite adaptations are unusual. This maintains the integrity of the original design solution.

Risk

Risk encompasses all aspect of a construction project and the DfMA approach reduces risk in many elements of the project; this is reflected in the reduced risk profile and risk allowance accepted by LOR in the delivery of The Grange. The LOR DfMA approach has been used on many other large healthcare projects including Brighton 3Ts, Clatterbridge, Alder Hey and Pembury.

The one team in-house integrated self-delivery model offered through DfMA for key packages, means that LOR have more control over their own destiny. Reducing reliance on third party subcontractors reduces the risk of claims, insolvency, misunderstanding and interface issues. As a result, the level of predictability of both cost and programme are improved and the interfaces between packages are improved as they have worked together previously and have an inherent understanding of each other's scopes, demarcation, handover procedures and are under the directive of a single point of responsibility.

Due to inherent understanding and belief in the integrity of subsidiary companies, there is a reduced level of duplication of preliminaries as the quality of personnel and reduction in man marking results in more funds being expended on the facility and less on time related staff costs.

There is a reduced reliance on wet trades and as such reliance upon the weather. The only key weather related risk with DfMA is wind downtime on use of cranes.

A significant item of risk, which is reduced significantly with DfMA is the volume of labour on site; the statistics for the saving of on-site hours is detailed in the programme section above. The overall benefit to on-site labour figures states that the volume of on-site labour for DfMA compared to traditional construction is reduced by 60%.

This also leads into the sequencing of works; strategic planning for the installation of larger components can be completed in order to facilitate greater programme certainty. Trade packages works are combined through components manufactured offsite and brought to site for installation reducing interfaces and thus improving sequencing.

The reduced number of subcontractor package interfaces facilitates a greater predictability of programme and cost as the component cost combines a number of trades and installation times are tested and known.

Reduced commissioning risk due to offsite manufacture of MEP risers, corridor modules, plant rooms and the integration of MEP services into walls. Elements can be tested and validated in the factory prior to bringing to site thus reducing risk of failure and generating greater certainty in the commissioning process.

Flexibility

One of the inherent challenges with healthcare buildings is the ongoing need to respond to changes in clinical demand, epidemiology, and evolving technology. One of the reasons concrete framed buildings, along with vibration benefits, are preferred for healthcare facilities is the flexibility an in-situ concrete frame allows for future adaptations. In discussions with the design team and LOR, the DfMA solution does inherently have an element of flexibility for changes in use, clinical function and adaptations; however, this is not as flexible as an in-situ concrete solution and will require careful review when considering future changes to the structure. An element of room future flexibility has been incorporated into the current design to cater for clinical and technological change.

DfMA does facilitate an improved flexibility for the commissioning programme as it improves predictability of programme. The overall reduction in programme also allows for flexibility in dealing with any third party delays.

Health and Safety

DfMA improves site safety in many ways. The first and most important factor in improving health and safety is the reduced number of workers on site during construction. The forecast labour saving between DfMA and traditional construction is 237,000 person hours (5,927 person weeks).

The prefabrication of components has the benefit of reducing the number of trade package interfaces during construction works on site. By combining several activities in controlled factory environments and bringing the completed component to site and fitting together simplifies the process and reduces the need for different contractors working together with labour on a busy construction site. The wider management and control of the site is improved with a reduced level of health and safety risk with a less congested site.

There is also a reduced level of waste generated, which not only has an environmental benefit but also means that waste is not generated on site, being moved around for removal and disposal. This improves general housekeeping on site and reduces the risk of trips, slips and falls.

DfMA simplifies the working processes with fewer large components being handled, which facilitates a more strategic approach with better planning and organisation. It also results in a significant reduction in scaffolding, reducing the number of operatives erecting maintaining and removing scaffolding and working at height during construction.

Whole Life Costs

There is a reduced maintenance of the DfMA products for the lifecycle of the facility due to production in a controlled factory environment and reduced incidence of on-site modifications, therefore, maintaining a greater integrity of the original design.

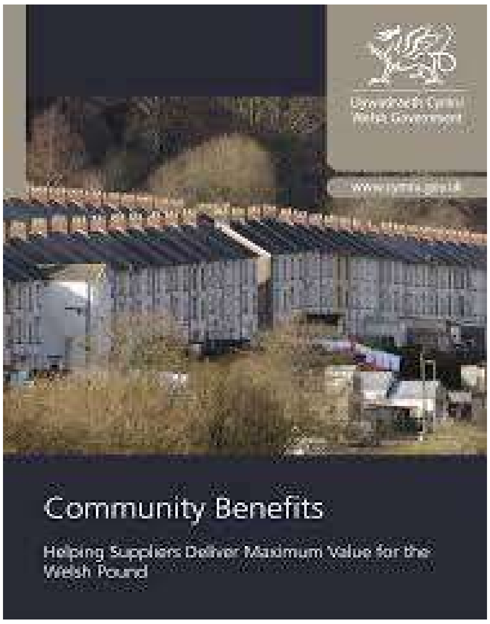
The greater robustness of factory components results in a reduction in planned preventative maintenance and reactive maintenance for the DfMA components.

Supply Chain Engagement

The available supply chain for traditionally procured solutions is extensive and well-established. As a consequence, for each trade package for a traditionally constructed building, an open book competitive tender process can be followed. The same cannot be stated for DfMA as these are delivered in a bespoke manner by in-house subsidiary companies. This can be seen as restrictive to some clients as they wish to have ultimate flexibility on available options.

The MMC market, whilst not embryonic does require development. One of the key barriers to success of MMC is the cost of establishing component off-site manufacturing facilities and the associated research and development cost that is required to both establish and continue to evolve and improve the MMC offering. This is primarily driven by the comparatively low volume of work delivered via MMC methods. LOR provide a robust and well-developed solution to MMC in the form of DfMA and the benefits of this can be seen; however, until MMC becomes a widely accepted and recognised approach to constructing new buildings the true benefits of MMC will not be fully realised.

Community Benefits



A structured community benefits approach underpinned the delivery of The Grange, which encompassed Enterprise, Employment, Resources, Community, Education and Training. The value of the contract related to goods, services and overheads was stated as just over £59m with £44m (74%) spent with businesses based in Wales, of which 6% were Small and Medium Sized enterprises.

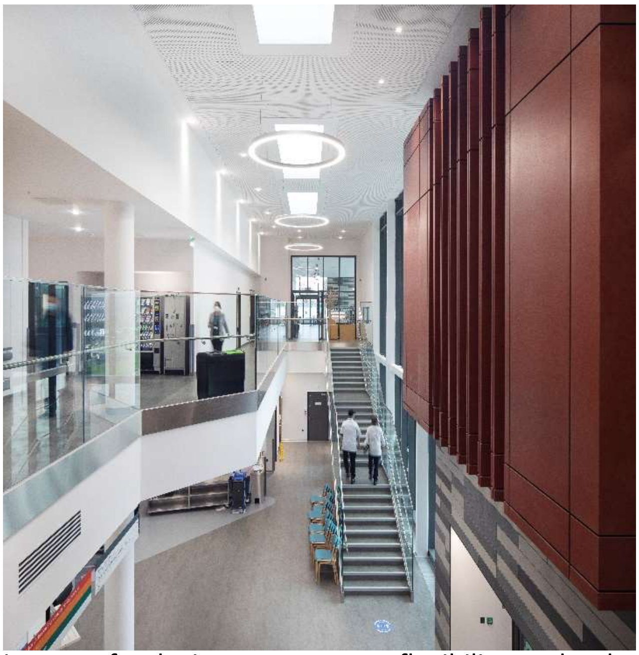
In relation to staff, 74% of salaries and wages were to people living in Wales and 72 staff living in Wales have been retained, 16 of whom were previously unemployed.

In addition, 10 non-accredited training opportunities were completed, and 20 non-accredited training weeks were provided during the period of this project.

4.0 Summary and Conclusions

There are many benefits that have been realised in the delivery of this project utilising DfMA as the means of construction. This case study identifies the benefits The Grange has benefitted from in the delivery of this project. We can see from the evidence presented that the duration of the programme has seen genuine time saving with over 23% programme saving due to DfMA and clearly improved level of predictability of programme, which has added benefits of equipment orders, commissioning and handover, employment and staff retention, training and correct sequencing of work.

Whilst cost is largely considered to be cost neutral with a balance between packages, preliminaries and risk; the predictability of cost is improved which enhances revenue generation, funding and cash flow forecasts.



Quality considerations of DfMA demonstrate the benefits of fabricating components in a controlled factory environment with reduced waste, better testing and more robust solutions meeting air tightness and fire integrity with the added benefit of improved whole life costing.

The risk profile is reduced with DfMA across many facets of the project; this is reflected in the contractor pricing of risk, which is lower than benchmark norms for a 2-stage design and build traditionally constructed healthcare project. The risk associated with Health and safety is also significantly reduced due to labour on site, sequencing of works, number of trade packages and methods of construction.

DfMA does have some dis-benefits. The key disbenefits are, a restricted supply chain, which has the impact of reducing procurement flexibility, and reducing competition; reduced flexibility for future structural and internal changes due to prefabrication of panels; current relatively low level of construction throughput with MMC components, which has the result of maintaining a higher cost base; whilst DfMA does provide a forward thinking and innovative solution, across the industry as a result of many of the above elements, this could be advanced further with greater use of DfMA and MMC enabling greater levels of research and development across the industry.

Whilst MMC may not be in its embryonic stages of development, it still has to develop further to glean the full construction benefits outlined in the Egan Report, 'Rethinking Construction' written in 1998 and the Government Construction Strategy written in 2011, which still stand as outlining the key criteria to generating improvements in the construction sector. Due to the volume of construction that is delivered using MMC, the level of research and development, competition and options is still limited. The medium to long-term goal would be to increase the volume of construction work delivered via MMC to create a more developed, flexible and open MMC offering to the market.

The balance of benefits of DfMA as an MMC solution, far outweigh the dis-benefits and with continued encouragement and investment in MMC solutions for use in construction projects, the dis-benefits can be reduced further and the full benefits of MMC can be realised.

Schedule of Appendices

Appendix A – List of Personnel Interviewed

Appendix B – List of Documents Reviewed

Appendix C – Standard Questionnaire

Appendix A - List of Personnel Interviewed

Nicola Prygodzicz - ABUHB

Mike Lewis – LOR, Project Lead

Tony Boak – LOR, Commercial Lead

David Leverton – LOR, DfMA Lead

Sarah Gealy – Aecom, MEP

Ian Bailey – Gleeds, Cost Advisor

Ross Andrews - ABUHB

Adrian Hitchcock – BDP, Architect

Stuart Renshaw – WSP, Civil & Structural

Simon Russell - NHS Wales Shared Services Partnership

Nigel Davies - NHS Wales Shared Services Partnership

Victoria Head – Gleeds, Project Manager

Appendix B - List of Documents Reviewed

Programme

Community Benefits Paper

Procurement Schedule

DfMA Strategy Document

DfMA Savings Document

Value for Money Report

Cost Report

Change Control Tracker

Early Warning Register

Health and Safety Plan

Stage 3 Design Report

Project Directory

Appendix C – Standard Questionnaire

Questionnaire

Design

1. Did DfMA improve design coordination?

2. Did DfMA shorten or lengthen the design period? For example was greater coordination required due to use of Smart walls or other components?

3. Was the design process simplified or complicated by the use of BIM?

4. Which design elements were undertaken by the supply chain?

5. Was a more robust stakeholder engagement process required with DfMA?

BIM

6. What level of BIM was adopted?

7. Did the use of BIM improve design sign-off?

8. Did BIM enable better clash detection?

9. Did the use of BIM improve buildability and reduce programme risk?

10. Was the BIM process improved due to DfMA and integrated supply chain?

Procurement

11. Was the decision to optimise the use of Modern Methods of Construction a key driver in the appointment of the contractor?

12. Was procurement simplified by the use of DfMA?

13. Was procurement quicker with DfMA?

14. Was the supply chain integral to the design process and did this improve buildability?

15. Have the benefits of DfMA been fully realised? If not where could this be improved?

16. Would NHS Wales use DfMA again?

Cost

17. Did DfMA improve cost predictability?

18. Did DfMA reduce the overall costs – which packages were more or less expensive than traditional build solutions?

19. NB: Review CEs and cost change to DfMA packages

20. Was marketed testing simplified with the use of DfMA?

21. Did DfMA impact the use of local labour and local companies?

22. What percentage of local labour and local businesses were used during construction?

23. What is the weekly time related preliminaries cost? And how much cost was saved due to preliminaries?

24. Did DfMA result in fewer suppliers and thus increase in cost for some components due to lack of competition? How was VfM demonstrated?

Construction/Programme

25. How much programme time was saved due to DfMA? Could this have been improved further and if so how?

26. Was buildability simplified saving time and cost?

27. Did the use of DfMA mean interfaces on site were easier to manage thus reducing risk and improving programme?

28. Did the steel frame and composite clad plant room improve (a) cost and (b) programme time?

29. Were all DfMA components tested off-site? Did this improve defects, level of replacements, save programme time and reduce cost?

30. How much programme time was saved installing windows into the pre-cast façade panels?

31. How much wind down time (percentage) was encountered with the cranes?

32. Were the number of cranes and duration of their use reduced due to DfMA? Did this reduce risk to the programme?

33. How much wastage of materials was there in the factory in the production of (a) lattice slabs (b) pre-cast façade panels (c) twin walls (d) MEP modular components.

34. Was wastage due to the building grid size, abnormalities in shape and/or integrating in-situ elements?

35. Did the use of DfMA provide greater predictability of (a) cost and (b) programme?

36. Was the commissioning period of 13 weeks held for commissioning?

37. How did Covid-19 impact the programme? Was this improved by use of DfMA?

38. Was production of DfMA elements impacted by Covid-19 and if so in what way and how much (cost and programme)?

39. What was the saving of labour on site compared to traditional building approaches?

40. Did the use of DfMA allow better integration between packages during site works?

41. Did reduction of wet trades improve programme – which components and how much time was saved?

42. Was there an improved overlap of critical path packages?

43. Did the use of DfMA improve quality of the final hospital?

44. Is there a zero-defect philosophy and did DfMA reduce the number of defects?

45. Has the snagging and defect resolution process happened progressively?

46. Was defect identification and resolution improved with the use of DfMA?

47. What was the overall time saving on site?

48. Could this have been improved upon?

49. How may reportable accidents were recorded on site during construction. Please also provide this as a per 1000 hours. How does this compare with the construction average and did the use of DfMA reduce risk?

50. Was there a reduced requirement for temporary works with DfMA?

51. Was there more repetitiveness in the design solution driven by DfMA – is repetitiveness requires to maximise the benefit?

52. Was the level of project risk reduced and if so how?

NB: The leading causes of private sector worker deaths (excluding highway collisions) in the construction industry were falls, followed by struck by object, electrocution, and caught-in/between. These "Fatal Four" were responsible for more than half (58.6%) the construction worker deaths in 2018, BLS reports.

Future Flexibility

53. Is future flexibility impacted in any way by DfMA compared with a traditionally constructed building? Moving walls, penetrations in slabs etc.?

54. Are future changes to MEP systems (modular wiring/plant etc.) restricted in any way?

Maintenance / Whole Life Costs / Sustainability

55. Were Whole Life costs improved with the use of DfMA?

56. Is maintenance improved with the use of DfMA?

57. How does the life expectancy of DfMA / MMC compare to traditional?

58. Is sustainability improved with the use of DfMA?