The Technical Challenges Involved in Lifting 40 Tonne Trucks Using Rigid Chain Technology in a Confined Space

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Abstract. This paper will describe the technical challenges involved in installing two 40 Tonne truck lifts in a theatre whilst utilising rigid chain technology (RCT) in a confined space. RCT is based on single interlinking chains comprised of single links. These links lock together when the chain is deployed, creating a rigid propelling column which when designed for the lift industry, means it is possible to design a lift which can transfer loads of up to several hundred tonnes.

It will explain how the project was procured from a consultancy perspective after the basic design of the building and lift shaft had been finalised, and on how reviewing the truck lift information, it became apparent that the design was incomplete and appeared impractical.

Areas examined include the applicable standards, anticipated loads to be lifted and evaluation of the various options for the truck lift design. It will include the results of the research that was undertaken whilst exploring the technology, energy efficiency, safety of the lifting systems and comparison sites where similar operational requirements had been used resulting in the decision to recommend RCT technology.

Illustrations of the challenges that were overcome during the design and installation process are included.

1 INTRODUCTION

This paper explains how the project was procured from a consultancy perspective after the basic design of the building and lift shaft had been finalised, and on how reviewing the truck lift information, it became apparent that the design was incomplete and appeared impractical.

The study looks at a number of areas including the applicable standards, anticipated loads to be lifted and evaluation of the various options for the truck lift design.

2 CLIENT REQUIREMENTS

The client, a major city council, decided to enhance their city's cultural appeal by planning to build a combined 1,700-seat theatre and 5,000-person auditorium on the same site. The proposed brownfield site straddled a road; therefore, the building was designed to have the theatre stage and auditorium on the same floor level, this floor level or performance level, (level 2) is 6.66m above road level (level 0).

The building was split into the areas shown below: (see fig. 1)

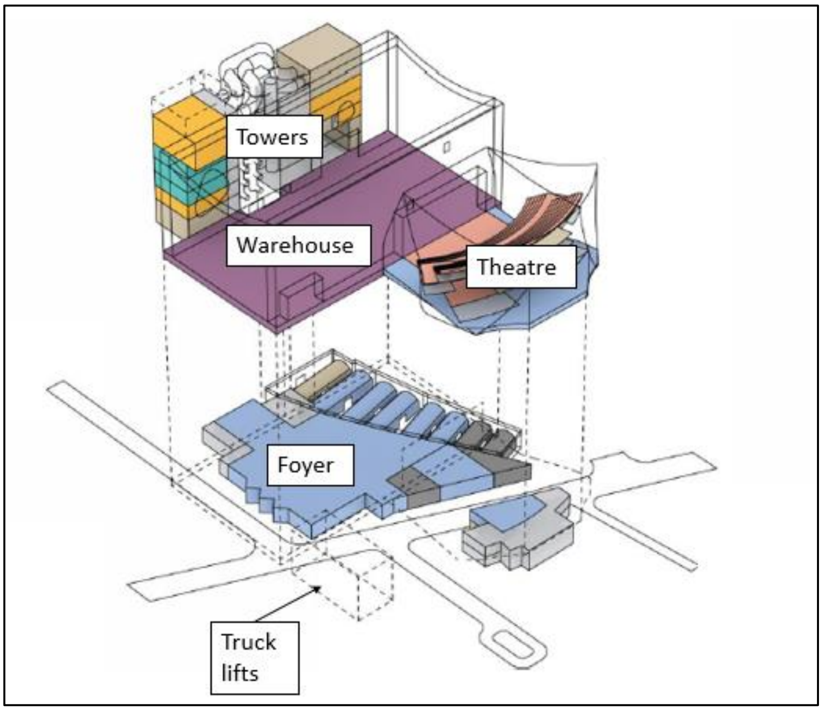

Figure 1 Layout of the building

To move trucks and equipment from road entrance level (level 0) up to the performance level (level 2) two truck lifts were proposed.

3 INITIAL CLIENT REQUIREMENTS

At the request of the client, a 'Sense Check' review was carried out on the finalised basic design of the building and shafts. Our review concluded that many areas of the design and operation were either incomplete, unworkable or impractical.

The 'Sense Check' covered the following areas:

A. The size of truck/trucks to be carried

B. The number of trucks to be moved per event

C. The method of loading and unloading the trucks into and out of the lift

D. The size of oversize production equipment and sets

E. The security of high value loads on the trucks

F. Whether the truck drivers could stay in their cabs or not

The results of initial 'Sense Check' report:

A. The size of truck/trucks to be carried:

It was established that the maximum truck size and weight allowed on UK roads as per UK and EU legislation was 16.5m length x 2.55m width x 4.4m height. A gross weight of 44 tonnes is permitted on UK roads however following discussion with the client a gross weight limit of 40 tonnes was applied as a maximum weight capacity of the lifts.

B. The number of trucks to be moved per event:

Research was carried out into the typical number of trucks used for a performance in a large warehouse space and with the assistance of the theatre operational team, the number of trucks to be moved for a performance was established at 20 trucks.

C. The method of loading and unloading the trucks into and out of the lift:

The client required the trucks to be able to drive directly onto the performance level floor which as previously discussed is 6.6m above the access road. In addition, the client required the facility to off load trucks from the rear of the trailers, using a system to provide an adjustable level access to the trailers (dock levelling position).

A tracking exercise was carried out by a specialist vehicle movement consultant, and they calculated that the trucks entering from the street would foul the entrance wall (A) or roller shutter guide (B) on the lift entrance. (See fig. 2)

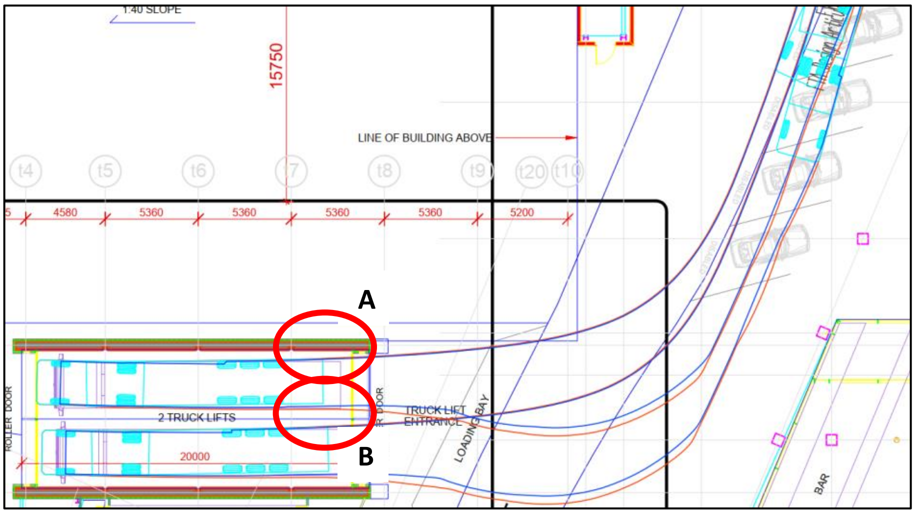

Figure 2 Truck tracking into the lift from the street

At the west end of the lifts there is a turning area (the Square), and the same exercise was carried out to establish the viability of trucks entering the lift from the Square. (See fig.3)

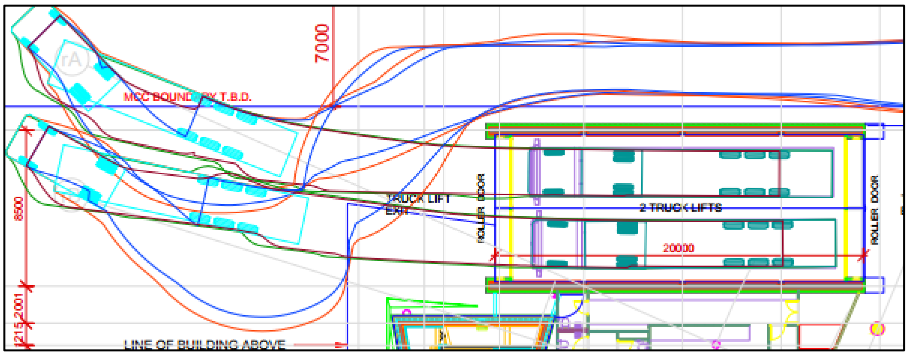

Figure 3 Truck tracking from the square

The tracking exercise established that the only feasible way for trucks to access the lifts was from the Square, by them reversing into the lifts as shown in the drawing extract above.

D. The size of oversize production equipment and sets:

The client's theatrical production staff were consulted on the typical maximum size of oversize production equipment, and it was confirmed that the equipment would be smaller than the proposed platform that would accommodate a 16.5m long truck. It was stipulated to the production staff that loads must not be allowed to lean on the side walls of the lift as they were not designed for any loads to contact them.

E. The security of high value loads on the trucks:

The client required high value loads to be unloaded from trucks at the dock levelling position without the trailer doors being opened outside of the building. To accomplish this the trucks had to be able to reverse onto the level 2 loading bay and open the trailer doors. The drawing extract (see fig. 4) shows the tracking required to achieve this and demonstrated it was achievable.

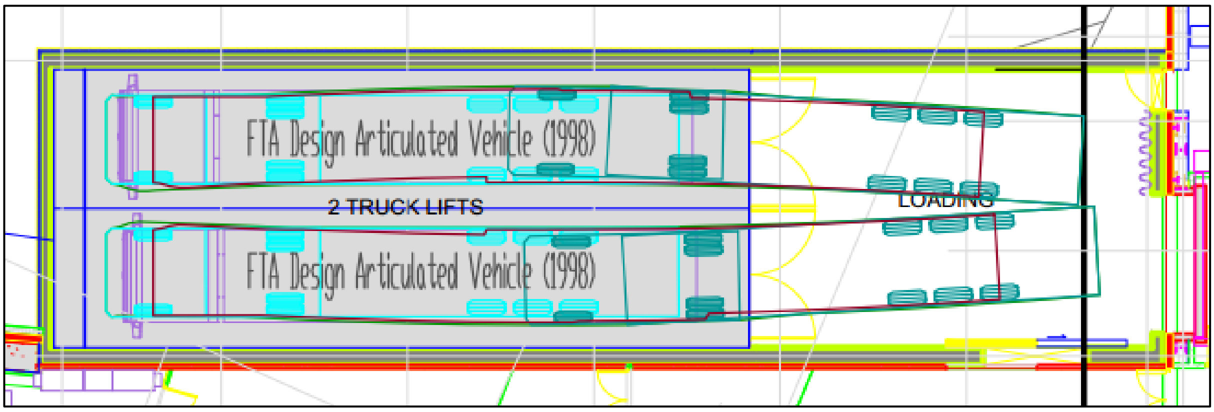

Figure 4 Tracking inside the lift.

F. Whether the truck drivers could stay in their cabs or not:

The initial designs for the theatre showed a staircase located adjacent to the truck lifts, however, this was removed from the scheme prior to our involvement. With the removal of the staircase the route for drivers and lift users to travel from the ground floor to level 2 without using the truck lift was convoluted. Further to this was the associated risk of getting lost or entering restricted areas whilst walking through the theatre.

The various regulations and standards were reviewed, and it was concluded that it would be acceptable for persons to travel on the lift platform if the necessary precautions and safeguarding features were installed, these features and precautions included:

- Installing controls on the lift platform to enable lift users to open the landing doors at floor level
- Defining the truck lift operation e.g., truck engine turned off when in position on the platform
- Ensuring there was minimal risk of fire on the truck during lift operation
- Providing a means of contacting rescue services in the case of lift malfunction or emergency, including means of communication (emergency and normal)
- Preparing a Personal Emergency Evacuation Plan (PEEP) for all personnel using the lift
- Providing a means for truck drivers to leave the lift when it was positioned at dock levelling position
- Other measures to ensure persons using the lift would be safe

A report was compiled with the above issues highlighted and proposed solutions, this was accepted by the client.

4 DESIGN DEVELOPMENT

The following areas and issues were reviewed to complete the design and installation of the truck lifts:

4.1 Researching and understanding the rigid chain technology

Rigid Chain Technology (RCT) is based on single interlinking chains comprised of single links. These links lock together when the chain is deployed, creating a rigid propelling column which, when designed for the lift industry, means it is possible to design a lift which can transfer loads of up to several hundred tonnes.

To ensure rigid chain technology was suitable for this truck lift application the following research was carried out.

The lifting systems reviewed:

- Hydraulic scissor lift (see Fig. 5)

Figure 5 Hydraulic scissor lift

- Rigid Chain System (RCS) – Serapid Ltd [1], (see fig. 6)

Figure 6 Underneath rigid chain system (during construction)

The results noted on site visits to a scissor lift and rigid chain lift and other research were as follows: (see table 1)

Table 1 Results of comparison between systems

	Hydraulic scissor lift	**Rigid chain system**
Space required for power pack	Large space required. Approx. space required 40m² x 4m².	No space required outside lift shaft.
Space required for control equipment.	Space adjacent to the lift shaft approx. 30m² x 3m high	Space adjacent to the lift shaft approx. 30m² x 3m high
Complexity of system.	Whole system operates at high pressure which creates higher likelihood of failure e.g. hydraulic hoses had been replaced on the scissor lifts visited on our evaluation exercise and the unit was less than 5 years old!	This system comprises of simple motor, gearbox and rigid chain arrangement; gearboxes, prop shafts, chain sprockets and rigid chain are all well understood technologies.
Dock levelling facility	The requirement to be able to 'inch' the lift for dock levelling would be problematical due to response of hydraulics.	The main motors have a variable voltage variable frequency drive and the 'inching' operation is easily accommodated.

Cooling equipment.	Air blast oil cooler mounted outside motor room of refrigerated oil cooler with external condensers.	Integral fan on the main motors.
Noise of system	Pump units very noisy and air blast oil cooler very noisy.	Minimal noise from main motors.
Maintenance	High levels of maintenance on hydraulic pump system.	Low maintenance requirement on entire system.
Cost of lift	Higher than RCS (commercially sensitive information)	Lowest price (commercially sensitive information)

The results above showed that the rigid chain lift had many advantages over the scissor lift. The scissor lift was ultimately discounted for the following reasons

- The project did not have an area large enough that could be used for housing the required hydraulic power units,
- The noise of the required oil coolers would be a serious issue due to close proximity of residential buildings,
- the cost of the scissor lift was higher than the rigid chain system,
- the 'inching' facility required for dock levelling operation would be difficult to achieve with the scissor lift.

To confirm that the rigid chain system met the client's requirements regarding noise, and to satisfy ourselves that the product was suitable for truck lift applications, site visits were arranged to a truck lift installation in Riga, Latvia and the Serapid [1] factory in Dieppe, France. Noise readings were taken during the site visit and were deemed satisfactory, and the factory visit met requirements.

4.2 Developing the truck lift design to suit the structural openings provided in the base build and later structural changes

The size of the lift shaft was 8m wide x 20m long (for both truck lifts) and was set during the planning stage of the project. There was no opportunity to increase it due to planning constraints and site limitations. The original design of the truck lift had manual swing gates both on the lift car and landings with additional security shutters on each end of the ground floor landings. These manual gates were impractical due to the number of staff required to operate them and the space required on the landings; it also precluded the dock levelling facility required by the client. The design was changed to have power operated shutter doors as the ground floor landing doors and an infrared curtain on the lift car. This automated the lift operation at the ground floor and maintained the area of the lift for the truck usage. On the upper level the manual gates were an issue and the design changed to a powered rising barrier which automated the operation on level 2 (theatre and performance level). During the design development and construction phase of the project, several structural design changes impacted the truck lift design, including restrictions on the ground floor roller shutter door motors not being allowed outside the building outside walls, circled in red. (See Fig. 7)

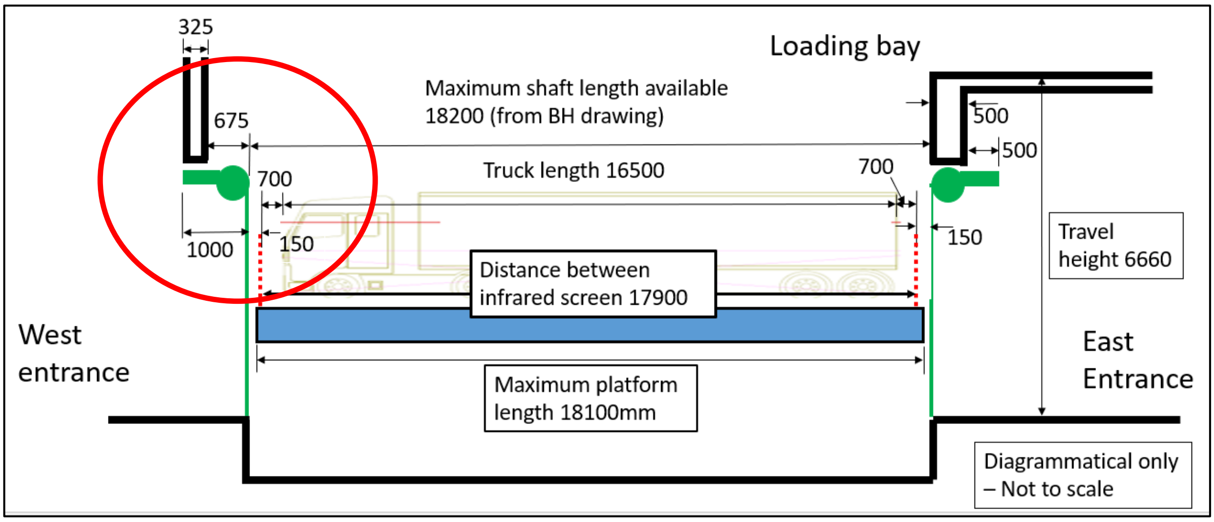

Figure 7 Ground floor roller shutter door motor issue.

Another structural change occurred with the rising barrier on level 2 being mounted on the face of the level 2 slab, this reduced the lift platform by 300mm.

4.3 Regulations, standards and codes the truck lifts must comply with

The overall lift is designed to comply with the Machinery Directive [2] and will operate at 0.075 m/second which is less than the Machinery Directive maximum operating speed of 0.15 m/second and will also comply with the British Standards regarding:

- Emergency communications – BS EN 81-28 [3],
- Safe working on lifts – BS 7255 [4],
- British Standard for new lifts complying with the Lift Directive – BS EN 81-20 [5] – where applicable. These areas included:
    - Safe operation and maintenance of the lift,
    - Features to enhance the passenger safety

4.4 Developing the method of operation including understanding truck tracking and manoeuvring

As previously described, the tracking of truck access to the lift was modelled by a specialist consultant. During the design development we were reviewing the tracking with every change in the design to maintain the usability of the truck lifts.

4.5 Liaising between the design team, client and truck lift manufacturer/installer and ensuring the truck lift design met the client's expectations during the design development

We acted on the client's behalf to ensure the functionality of the lifts and the requirement to move 40 tonne trucks was maintained. We frequently challenged changes in design that would affect the size of the lift.

One of the lifts has now been used to move a 40 tonne truck during construction operations (beneficial use).

4.6 Acting as the lift specialist adviser to the project

A lift company was originally leading the rigid chain design and installation, but this company decided to withdraw midway through the design of the project, so the installer (who also was the manufacturer of the platforms and controls) stepped up to lead the project. The installer had experience of a truck lift overseas but limited knowledge of UK lift standards and codes, so we are providing lift expertise, knowledge and guidance to the contractor.

4.7 Integrating the truck lifts operation with the fire strategy of the building

The fire strategy had been prepared by the fire engineering consultant and included the main riding function of the lift. During the development of the fire strategy the document was revised and the function of the driver staying in their cabs had been removed without reason. Meetings and discussions took place with the fire consultant, and we drew up a fire cause-and-effect table which identified operational measures that are required to check the vehicle for smoke or fire before entering the lift and what shall happen if a fire is detected whilst the lift is in travel. This cause-and-effect table demonstrated that the drivers were not at risk and was accepted by the fire consultants.

4.8 Developing the Personal Emergency Evacuation Plan (PEEP) for the truck occupants who would be staying in their cabs during the lift operation

As part of the requirement for the drivers to stay in their cabs, a Personal Emergency Evacuation Plan (PEEP) was developed, this involved:

- Identifying persons covered by this PEEP
- Identifying areas of safety/refuge
- Determining safe routes to a place of safety
- Names of anyone appointed to assist the person in an emergency
- Listing specialist equipment that may be necessary
- Identifying where staff training is needed
- Detailing when and how escape practise will take place

Once formulated, the PEEP was circulated to the design team and client for review and comment. There were no comments and the PEEP was adopted.

4.9 Developing the test and commissioning plan including the use of 40+ tonne test weights

The test and commissioning plan was developed to demonstrate to ourselves (representing the client) that the lift operated satisfactorily in normal and test conditions, these were:

- Contract load normal operation and emergency stop – 100% contract load – 40 tonnes
- 10% overload operation and emergency stop – 110% of contract load – 44 tonnes
- 25% overload – lift held on brakes – 125% of contract load – 50 tonnes

The test and commissioning plan is yet to be completed and includes:

- Review of completed test sheets
- Review of test instrumentation and calibration certificates
- Normal operation e.g., doors, etc.
- Current readings compared with test sheets
- Lift operation and levelling including dock levelling operation

A complete defect inspection will be carried out on each lift.

4 CONCLUSION

Rigid chain technology provides an excellent solution to applications such as truck lifts. It has the advantage of being very simple and quiet in operation.

Lessons learnt:

- Involvement in the project at an early stage is essential to avoid having to compromise the lift design to fit the available space
- The lift design company must have a full understanding of lift standards and codes
- The whole design team must sign up to the minimum lift platform size and size of vehicle to be moved

REFERENCES

[1] Serapid Ltd, The Counting House, Elm Farm Park, Great Green, Bury Saint Edmunds

[2] The Supply of Machinery (Safety) Regulations 2008 (Directive 2006/42/EC)

[3] BS EN 81-28: 2003 *Remote alarm on passenger and goods passenger lifts (London, BSI)*

[4] BS 7255: 2012 *Safe working on lifts (London, BSI)*

[5] BS EN 81-20: 2020 *Safety rules for the construction and installation of lifts – Lifts for the transport of persons - Passenger and goods passenger lifts (London, BSI)*

BIOGRAPHICAL DETAILS

Philip Pearson is the Managing Director of UK based lift and escalator consultants Pearson Consult Ltd. He has been in the lift and escalator industry since 1986 having previously been a building services engineer. Philip has experience of the lift industry from all aspects; from a client perspective – responsible for all lifts and escalators at a large department store group – forming and running a lift and escalator company, designing lifts and escalators for a lift manufacturer and 20 years as a lift and escalator consultant, the last 7 of which has been operating his own practice. Philip is an active member of CIBSE, this includes being committee member and Papers Chair for CIBSE West Midlands region, responsible for organising and delivering CPD to the region and nationally and member of the CIBSE Lift Group Executive Committee responsible for organising northern events.