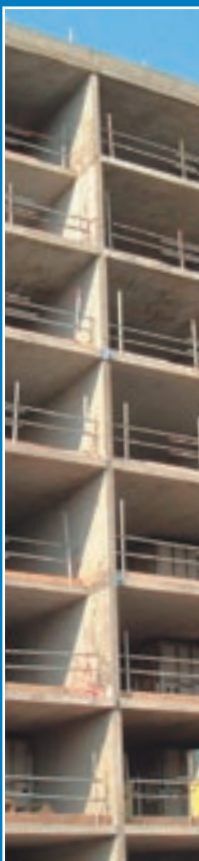
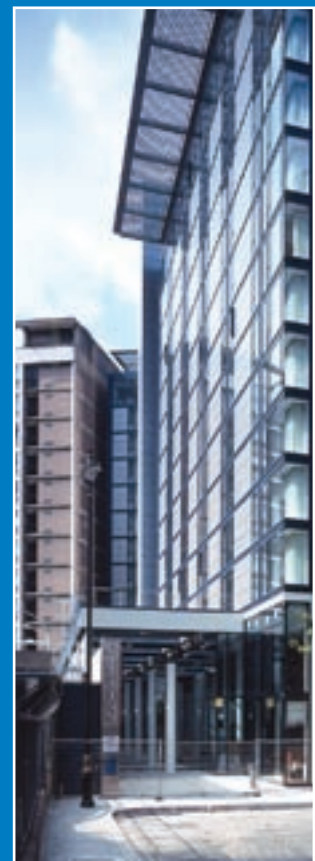




The **Concrete** Centre™

High Performance Buildings

USING TUNNEL FORM CONCRETE CONSTRUCTION



For cellular buildings that...

... ARE FAST AND ECONOMICAL
TO CONSTRUCT

... ARE FLEXIBLE IN DESIGN

... HAVE ALL THE VALUE AND
BENEFITS OF CONCRETE

**Tunnel form construction makes
an excellent choice.**

Front cover (left to right):

- Millenium Plus – see Case Study on page 5
- City Inn, Westminster
- Queen Mary and Westfield College – see Case Study on page 4

This page:

Days Inn, Glasgow



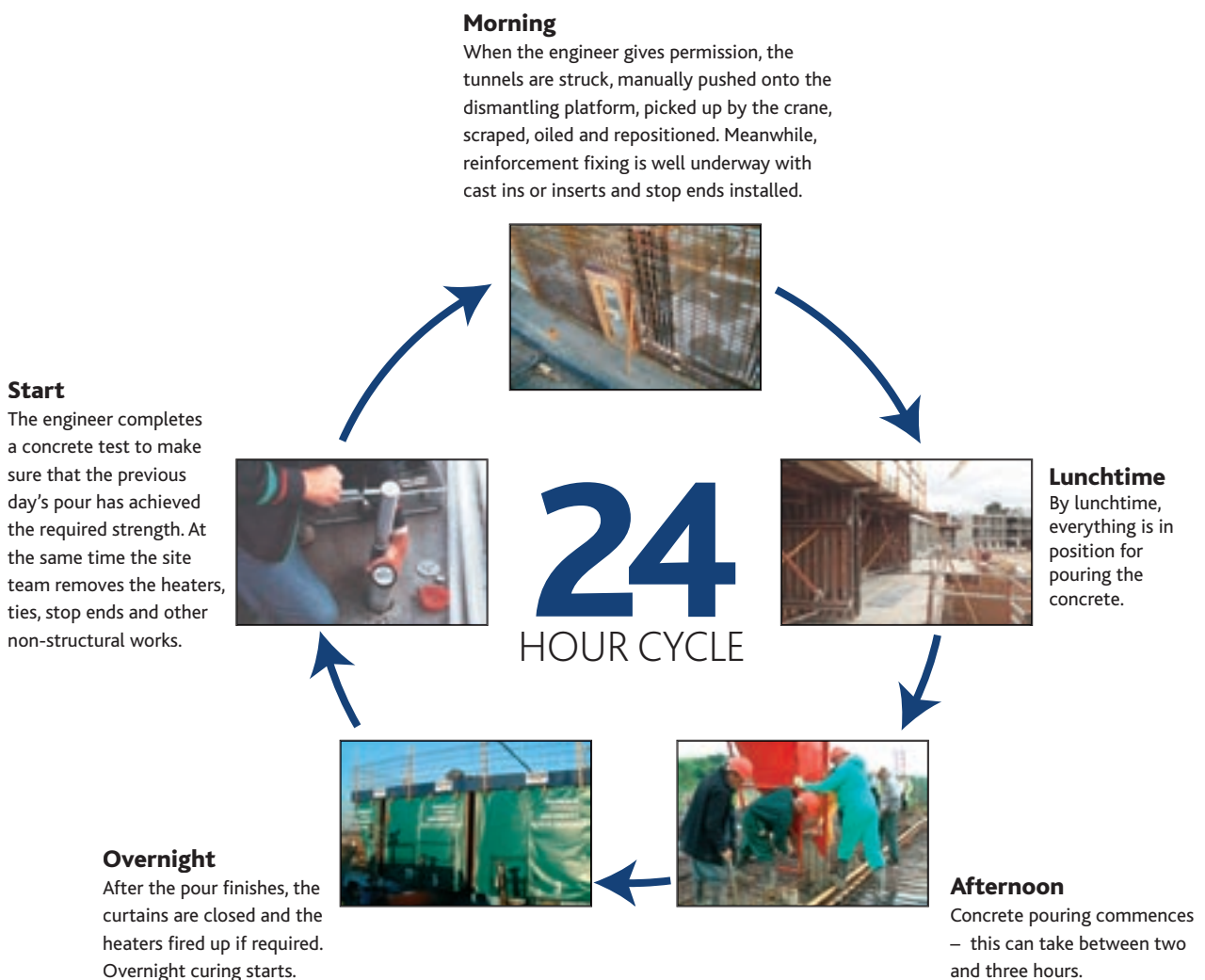
WHAT IS TUNNEL FORM CONSTRUCTION?

Tunnel form is a formwork system that allows the contractor to cast walls and slabs in one operation on a daily cycle. It combines the speed, quality and accuracy of factory/off-site production with the flexibility and economy of in-situ construction and is recognised as a Modern Method of Construction (MMC).

The result is a cellular reinforced concrete structure, the surfaces of which are of sufficiently high quality to require only minimal finishing for direct decoration, while the end walls and façades are easily completed with thermally insulated units that can be clad as required.

The system creates an efficient load-bearing structure for use in a wide variety of applications. It is particularly effective in projects suited to repetitive cellular construction such as residential blocks, hotels, student accommodation, barracks and prisons. The solid, strong monolithic structure can be 40 or more storeys in height and the accuracy of the system suits the installation of prefabricated elements such as cladding panels and bathroom pods, offering further MMC options. In Europe, tunnel form construction is competitive for much smaller projects such as blocks of six apartments but is yet to be used on that scale in the UK.

The steel tunnel forms create spaces spanning 2.4 to 6.6 m. These can easily be subdivided to create smaller rooms. Where longer spans (up to 11 m) are required the tunnel form is extended using a mid-span section.



Tunnel form construction can provide:

- Substantial savings in costs
- Substantial savings in labour
- Much faster construction
- Enhanced safety
- Better management control
- Predictable work flow
- Quicker return on investment
- Precise, high quality structures
- Design flexibility

...and all the added value of concrete

Diagram showing the typical two-day progress of construction

THE BENEFITS OF USING TUNNEL FORM CONSTRUCTION

The UK is rapidly adopting the tunnel form system for hotel and student accommodation and social housing. The UK construction industry has been alerted by Egan and Latham to adopt modern methods of construction. The building process can be completed efficiently, economically and faster with benefits for everyone concerned.

The tunnel form system exploits these principles to provide cost-effective, high quality construction, generating significant savings in time and costs over alternative methods without compromising on design. Tunnel form projects have proved that impressive results can be achieved in productivity, efficiency, economy and quality. The system is now one of the most preferred methods of cellular construction with architects, engineers and contractors throughout the world, whilst clients appreciate tunnel form's ability to deliver projects to budget and on time.

Costs

Value engineering starts with the early involvement of the formwork supplier. The formwork is available to the contractor for purchase or rent and can be reused on other projects. Not only does tunnel form often reduce the cost of the frame by over 15%, its application provides construction efficiencies resulting in an average savings of 25% in the time taken to complete the frame. The resulting monolithic construction can also produce savings in the foundations.

Productivity and control

The formwork is specially adapted for each project. The repetitive nature of the system and the use of prefabricated forms and reinforcing mats/cages simplifies the whole construction process, producing a smooth and fast operation. The techniques used are already familiar to the industry, but with tunnel form construction there is less reliance on skilled labour. On average, a team of nine site operatives plus a crane driver can strike and fix 300 m² of formwork each day, including placing approximately 35 m³ of ready-mixed concrete. The work can continue in all weather except high winds, and heaters can be used to accelerate the concrete curing process.

The schedule provided by the 24-hour cycle means each operative knows exactly what to do and when, and works to a precisely detailed plan. The smaller work teams and predictable, measurable daily production rates simplify and enhance overall control of the project. Known completion times make scheduling of material deliveries and follow-on trades more accurate and optimise cash flow by facilitating 'just in time' principles. By quickly providing protection, the system allows the following trades to commence work on completed rooms while work proceeds on upper floors.

Quality

Quality is enhanced despite the speed of construction. The precise, even steel face of the formwork creates a smooth, high quality finish capable of receiving direct decoration with the minimum of preparation (a skim coat may be required). This reduces the requirement for finishing trades, thus providing additional cost savings and speeding the entire process.

Design

The large bays constructed using tunnel form provide exceptional flexibility in the design and layout of the building and allow a high degree of freedom in the final appearance. The elevations can be adapted by using extendable formwork to create cantilevered balconies and the exterior can be finished in any way the architect requires, from brick slips on highly insulated framed infill panels, to sophisticated curtain walling systems.



The high levels of dimensional accuracy achieved with tunnel form and the superior load distribution result in a strong, solid monolithic structure suitable for a multitude of uses. The ability to create clear spans up to 11 m wide provides the opportunity to use non load-bearing internal partitions that can be moved to provide alternative layouts.

Safety

Tunnel form has integral working platforms and edge protection systems. In addition, the repetitive, predictable nature of the tasks involved encourages familiarity with operations and, once training is complete, productivity improves as construction progresses. The minimal requirement for tools and equipment when moving the tunnel form further reduces the risk of accidents on site.

Comprehensive method statements from the formwork suppliers and a full safety risk assessment enhance safety in tunnel form's application. The system meets all the current Health & Safety construction site requirements. In addition, for the client and end user, the superior fire resistance and strength inherent in concrete structures increases confidence in the building itself.

Environment

In today's environmentally conscious society, we are under ever-increasing pressure to reduce waste and provide energy efficient buildings within sustainable communities. Tunnel form provides benefits in key areas:

- The in-situ casting of units on site and the local availability of ready-mixed concrete supplies reduce transportation impacts.
- Just-in-time deliveries and near zero wastage produce an overall tidier site with associated cost savings and safety benefits plus minimum disruption where the site is already partly occupied.
- Concrete's thermal mass coupled with correct insulation and boiler design minimises heating costs and can even reduce air-conditioning requirements, with the resultant benefits for the environment.

The monolithic and accurate structure facilitates airtight construction – an expected requirement in the 2005 amendment to the Building Regulations, Part L.

- Direct finishes and durable walls minimise decoration, repair and refurbishment costs. Wallpaper can be directly applied or a skim coat may be used to provide a perfect plastered finish.
- In combination with the correct flooring and ceiling systems for separating floors, tunnel form floors can use the Part E Robust Detail No. E-FC-2 and be confident of passing the pre-completion testing (PCT) required for Part E sound insulation. With tunnel form, party walls are simple and can be made of the concrete itself or be non load-bearing demountable partitions of lightweight concrete block work, or plasterboard systems. All of these require PCT with a range of suggested options in the Part E document or from the acoustic specialist, which should satisfy the new requirements.

Ease of service installation

Service runs can be pre-installed before the concrete is poured. Other facilities such as bathroom pods can be installed as completed units using existing access platforms.

Modern Methods of Construction (MMC)

The use of tunnel forms brings factory quality and efficiency to site and so is recognised as a Modern Method of Construction under the initiative being promoted by the ODPM. Referenced in Housing Corporation documentation, it is eligible for use by Housing Associations as an MMC system.

Support

The tunnel form suppliers/contractors provide full design and technical support to ensure engineers, architects and site staff are all familiar with the system and its application as the project starts, enabling time and cost savings to be achieved. If the site staff is inexperienced with tunnel form construction, the supplier's site training quickly brings them up to speed.

ACOUSTIC TEST REPORT

The new tunnel form block of student accommodation at the University of East Anglia was acoustically tested in August 2004 with excellent results.

Although not domestic residences, university halls, hotels and hostels all have to comply with the new Building Regulations Sound requirements of Part E 2003. They will not be permitted to use the Robust Detail route and will have to undergo pre-completion testing (PCT). As a monolithic structure, tunnel form is one of the few systems that should be totally repeatable and therefore can be used with confidence on future projects using the same construction details.

Two separating floors in the new block, consisting of 250 mm of concrete with a stuck-down carpet and no ceiling finish beneath, were tested. They both exceeded

the regulations by more than 5 dB for both airborne and impact sound insulation (actually meeting the levels required by Robust Details). Had a floating floor and suspended ceiling been incorporated the results would have been even better.

Two separating walls were also tested, each comprising 180 mm concrete with a 2 mm plaster skim finish. Both met the PCT requirement and could have exceeded it further with the addition of wall linings.

This test, no 040901, carried out by an independent acoustic expert, is downloadable from the Residential section of The Concrete Centre website www.concretecentre.com.



CASE STUDIES

Three different projects spanning the student, hotel and housing markets demonstrate the versatility of tunnel form construction in delivering quality and speed.

Queen Mary and Westfield College: cells complete for following trades to commence.



STUDENT ACCOMMODATION FEATURING THE UK'S LARGEST TUNNEL FORM SCHEME

Project description

The concrete shells for this village of six blocks for [Queen Mary and Westfield College, University of London](#), varying in height from four to eight storeys, were constructed to a fast-build programme within 26 weeks. The finished buildings contain apartments with bedrooms and dining room/kitchens, offering a range of accommodation for 1000 students.

Why tunnel form was chosen

The repetitive nature of student housing lent itself to a factory-on-site production system, exemplified by tunnel form. The design-and-build contract allowed the team to optimise construction processes. Ten different construction options were considered for economy and speed by structural engineer, Adams Kara Taylor, before tunnel form was chosen. Cost, as always, was a key driver in this project. Fire and sound resistance were also deciding factors in favour of concrete. After looking at its use in some recent projects, contractor Laing O'Rourke concurred with the design team's choice of tunnel form and was confident enough to purchase the specialist formwork system and reuse it on a later project at Holloway College.

Construction

The construction was planned around the tunnel form 24-hour cycle, using two sets of tunnels, each producing two bays, as its requirements would drive the programme. The dimensionally accurate and modular nature of the system led to the choice of bathroom pods, which eliminated repetitive trade fixing. Two bays, typically 6.3 m wide by 10.3 m deep, were constructed in each cycle. After subdivision each produced six study-bedrooms and a dining room/kitchen. The contractor's teams were able to master the system within one week, producing the high quality finishes required. Cladding and internal panels were prefabricated or pre-cut. This was made possible by the tight dimensional control of the system, saving time and money and eliminating waste. Where possible, services were run in these panels and trunking to minimise buried ducts in the concrete. Good planning and management are an integral part of the system, and on this project three cranes were used to ensure timely movement of materials and formwork.

Special interest

The superstructure - frame, floor slab and internal walls - for a 175-bedroom block was built in only 32 days. Throughout the contract waste ready-mixed concrete amounted to only 0.15% of the total delivered.

What tunnel form brought to the project

Tunnel form brought a factory production line to site, and the resulting dimensional accuracy, quality finishes and predictable fast output encouraged prefabrication and forward planning of processes and materials delivery. This extended to the contractor fitting out the bedrooms, complete with beds, in addition to the bathroom pods. Students and the client will reap the benefits of concrete construction, including good acoustic performance, excellent fire resistance, high thermal mass and low maintenance, all achieved within budget.

"The tunnel form system is amazing... things just seem to appear out of nowhere."

Ken Kinsella, client project manager, Queen Mary and Westfield College.

"A superb system; the way the industry will move forward..."

Gordon Latimer, Laing O'Rourke's project manager.

A NEW FIVE-STAR HOTEL BEHIND HISTORIC FAÇADE

Project description

The Radisson Edwardian Hotel, Manchester, a 268-room, five-star hotel, has been built behind the listed building façade of the Free Trade Hall, a landmark Victorian building in the heart of Manchester. There are two blocks connected by a glass atrium, which provide function and public rooms. Behind the façade, and replacing an uninspiring 1950's structure, is a new 16-storey tower built using the tunnel form system.

Why tunnel form was chosen

Approvals for this sensitive site took more than seven years, with Arup providing structural, geotechnical, acoustic and M&E services. The consortium of Alfred McAlpine Special Projects and Laing O'Rourke chose tunnel form for the bedroom block as its cellular form and operation suited this congested city centre site. Speed of construction and cost, plus the fire, acoustic and thermal mass properties of the tunnel form concrete's 225 mm slab and 200 mm walls sealed the deal.

Construction

Four rooms were cast each day, six days a week. One team carried out the formwork, reinforcement and concreting activities. The 24 hour cycle required high early strength for striking – 15 kN was typically achieved by early morning (see 24-hour cycle on page 1). The concrete mix was tailored to suit the needs of pumping to a height of 15-storeys, in addition to those for early strength, good workability and finishes, and the growing summer heat.

What tunnel form brought to the project

A five-star hotel needs to be seen as superior, and tunnel form concrete met the high demands for building performance and quality, such as excellent acoustic performance of walls and floors. At the same time, it matched the consortium's needs for construction speed, value, and operational flexibility within this difficult and historic site.



The new tunnel form Radisson Hotel behind its historic façade.

MAJOR LONDON REGENERATION PROJECT

Project description

Millennium Plus at the Nightingale Estate, Hackney, is a multi million pound regeneration project, comprising several hundred new houses and flats for rent, shared ownership and open market sale. The Southern Housing Group worked in partnership with the Council, designers Watkins Gray International, Philip Pank Partnership cost consultants and Countryside in Partnership. The first new homes were completed in 2001, with the entire regeneration project due to finish in 2008. This Housing Forum Demonstration Project harnesses resident involvement in design, innovative construction, partnering and the early involvement of contractors to improve efficiency and space standards and reduce costs in use.

Why tunnel form was chosen

Formwork has significant effect on a project's economics and construction speed, so tunnel form was used for the in-situ concrete structure to achieve a fast construction programme with thermal mass, high sound insulation properties and inherent fire resistance. The system effectively brought a factory production line to site, with its accuracy, speed and quality allowing prefabricated insulated frame wall panels for the front and rear elevations. An open loft space is provided by the concrete spine walls covered by a factory-made roof panel that was craned into position. These innovations aimed to reduce the construction period by six weeks.

Construction

Concrete piled foundations and ground beams support the reinforced concrete tunnels that form the structure from ground floor level to the ridge of the roof with 200 to 230 mm thick walls, and floors between 175 and 250 mm thick. The structure is cast one floor at a time in situ, using long life factory-made steel tunnel formwork designed to suit a variety of dwelling module sizes. The process produces a complete building structure of floors and party walls from ground level to ridge level. The structure is then ready to be enclosed with a highly insulated envelope.

What tunnel form brought to the project

Tunnel form and in-situ concrete have contributed significantly in providing:

- Strong and durable walls, with high acoustic performance.
- Innovative, spacious and user friendly design, with large open plan lofts.
- Good site productivity - the predictable daily cycle allows efficient material supplies and use of follow-on trades with cast-in services.
- High quality finishes, enabling exposed concrete surfaces for high thermal mass and airtight construction, helping to achieve heating and hot water costs of around £3 per week for a large three-bedroom house.



Shared ownership flats at the Millennium project, showing the bay windows achieved by modifying the formwork.

Photo: Southern Housing Group

“The residents appreciate the useful clear loft space, floors which don't squeak, and they really like the look of the new homes. Thermal and sound insulation is good, too.”

Jill Beaver, client project manager, Southern Housing Group.

CI/SfB			
UDC	69.057.52:728.5		



Chelsea Village Hotel, London.

CPD presentations on concrete and tunnel form construction are available on request. Please call 0700 4 500 500 or 0700 4 CONCRETE, or email residential@concretecentre.com



The **Concrete Centre**™

www.concretecentre.com

The Concrete Centre, Riverside House,
4 Meadows Business Park, Station Approach, Blackwater, Camberley, Surrey GU17 9AB
National Helpline 0700 4 CONCRETE or 0700 4 500 500

Ref. TCC/04/02

ISBN 1-904818-11-0

First published 2004

© The Concrete Centre 2004

Advice and visual material supplied by Ischebeck Titan and Southern Housing.

All advice or information from The Concrete Centre is intended for those who will evaluate the significance and limitations of its contents and take responsibility for its use and application. No liability (including that for negligence) for any loss resulting from such advice or information is accepted. Readers should note that all Centre publications are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.