Case Study 6 Supplying a city construction site with concrete

A CONSTRUCTION END-TO-END FREIGHT JOURNEY

A Construction End-to-End Freight Journey considers the supply of concrete to an urban construction site; in this case from the dredging of aggregates in the English Channel to the final delivery in London. It focuses on current industry practices, efficiencies, causes of delay, delivery challenges, modal shift and issues that the industry faces. The case study is based on discussions with concrete producers and retailers and reflects a common end-to-end journey. The journey is not intended to carry the weight of statistical evidence; rather, its purpose is to illustrate some of the common issues faced by freight operators and to assist readers in understanding where opportunities for efficiency improvements may exist.

Introduction to concrete

Concrete is the most common and utilised construction material in the world. It is usually made from mixing sand and gravel (drawn from aggregates) with cement and water. Thorough mixing of these elements is essential for a uniform mixture and, once mixed, wet concrete must continue to be turned to ensure consistency of product and poured within two hours. For these reasons concrete producers position their concrete mixing plants close to both aggregate processing sites and major population centres where much of the concrete will be poured. Concrete mixers typically travel within a 6-10 mile radius of the concrete mixing plant.

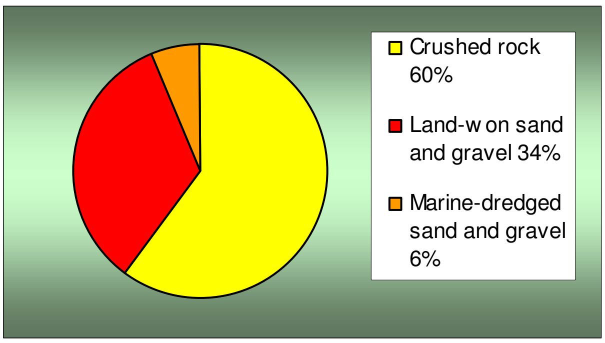
Aggregates

Aggregates comprise of crushed stone material, gravel, sand and other quarry products. They are extracted from quarries or dredged from the sea and are used for various purposes in the construction industry: road building, cement, ready-mix concrete, concrete products and asphalt. Britain consumes 204 million tonnes of aggregates annually. It exported 3.2 million tonnes in 2003 and imported 2.6 million tonnes (half from Norway). Most of the imports were shipped by sea to south east ports (British Geological Survey, 2005).

Courtesy of Cemex

Britain has large inland depositories of hard rock suitable for aggregates primarily in the north of England. In the south and south east, where the demand for aggregates is highest, there is no hard rock available for aggregates. For this reason there are high volumes of aggregates transported by rail and road in Britain (British Geological Survey, 2005). Figure 1 shows the source of Britain's aggregates by percentage, based on the 204 million tonnes of primary aggregates sourced in 2003. "Land won" sand and gravel refers to aggregates that are mined from quarries.

Figure 1: UK indigenous source of aggregates



Source: Office of National Statistics (2004)

- About 3 million tonnes of aggregates a year are transported by sea from UK quarries to destinations principally in South East England.
- Over 22% of total aggregate sales are in London.

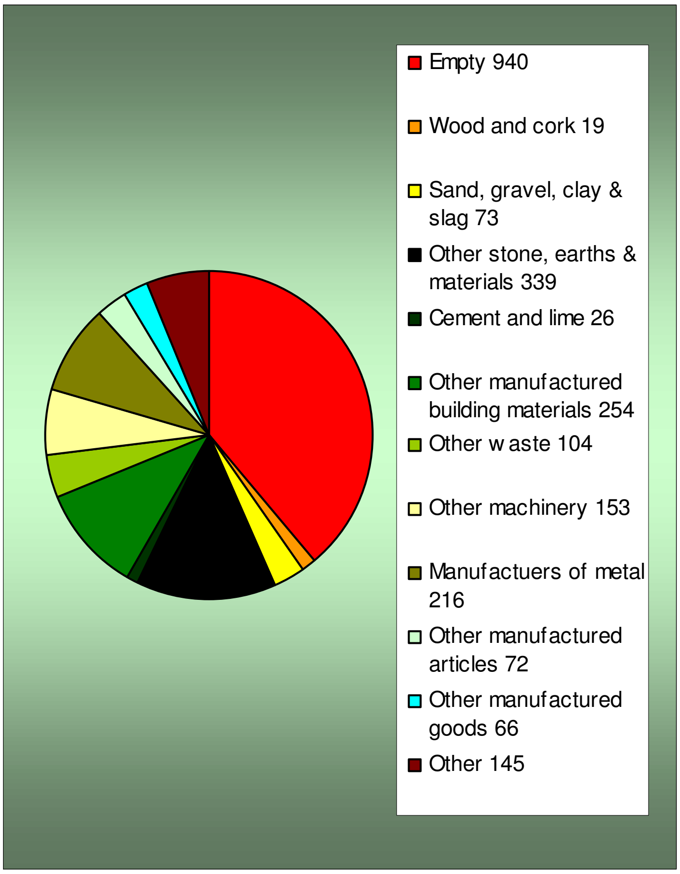
Cement

Limestone and other additives are heated at a high temperature and rapidly cooled to produce cement clinker. The clinker is mixed with gypsum and finely ground to produce cement. Cement is used to bind the sand and gravel to the water to produce materials such as concrete. About three-quarters of cement is used to produce ready-mix concrete, or concrete products, and more than 90% of cement used is produced in the UK.

Key facts about transport in the construction industry

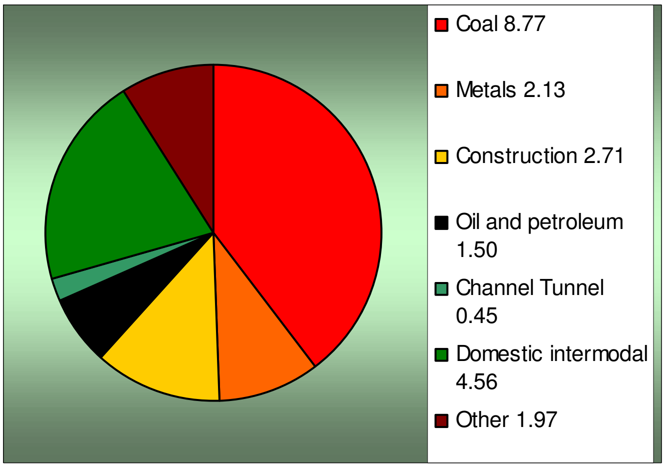
- Between 2004 and 2006, sand, gravel, clay and slag was moved 789 million vehicle kms on the road (CSRGT, DfT 2006).
- Between 2004 and 2006, cement and lime was moved 494 million kms on the road (CSRGT, DfT 2006).
- 2.4 billion vehicle kms were attributed to the construction sector between 2004 and 2006. This represents 8% of all road freight vehicle kms (CSRGT, DfT 2006). Figure 2 shows a breakdown of the 2.4 billion vehicle kms by commodity and highlights where the most vehicle kms are within the construction industry (own account drivers only).

Figure 2: Vehicle kms in construction: commodities moved (own account only): 2004-2006 (million kms)



Source: Continuing Survey of Road Goods Transport, DfT (2007)

Figure 3: Rail freight moved: 2006-07 (billion net tonne kms)



Source: National Rail Trends Yearbook, Office of Rail Regulation (2008)

- In 2006-07, 2.71 billion tonne kilometres of construction materials were moved by rail in Britain: a decrease of 6% from the previous year (ORR, 2008). Construction totalled 12% of all freight moved by rail. Figure 3 shows the share of construction against all categories of freight moved by rail in 2006-07 (the total moved by rail was 22.11 billion net kms).
- Construction materials moved by rail typically includes quarried materials such as aggregates and limestone.

The large percentage of empty running on the road in Figure 2 reflects the nature of the industry and the fact that there are few opportunities to utilise return journeys of specialised vehicles such as cement mixers or aggregate tippers.

Employment in the construction sector

Between 1996 and 2004 there has been a 30% increase in jobs in the construction industry with a total of 1,165,077 construction jobs in 2004. By comparison, the transport, storage and communications sector has grown by 16% with 1,568,512 jobs in 2004 (Source: MDST and official labour market statistics).

The scenario

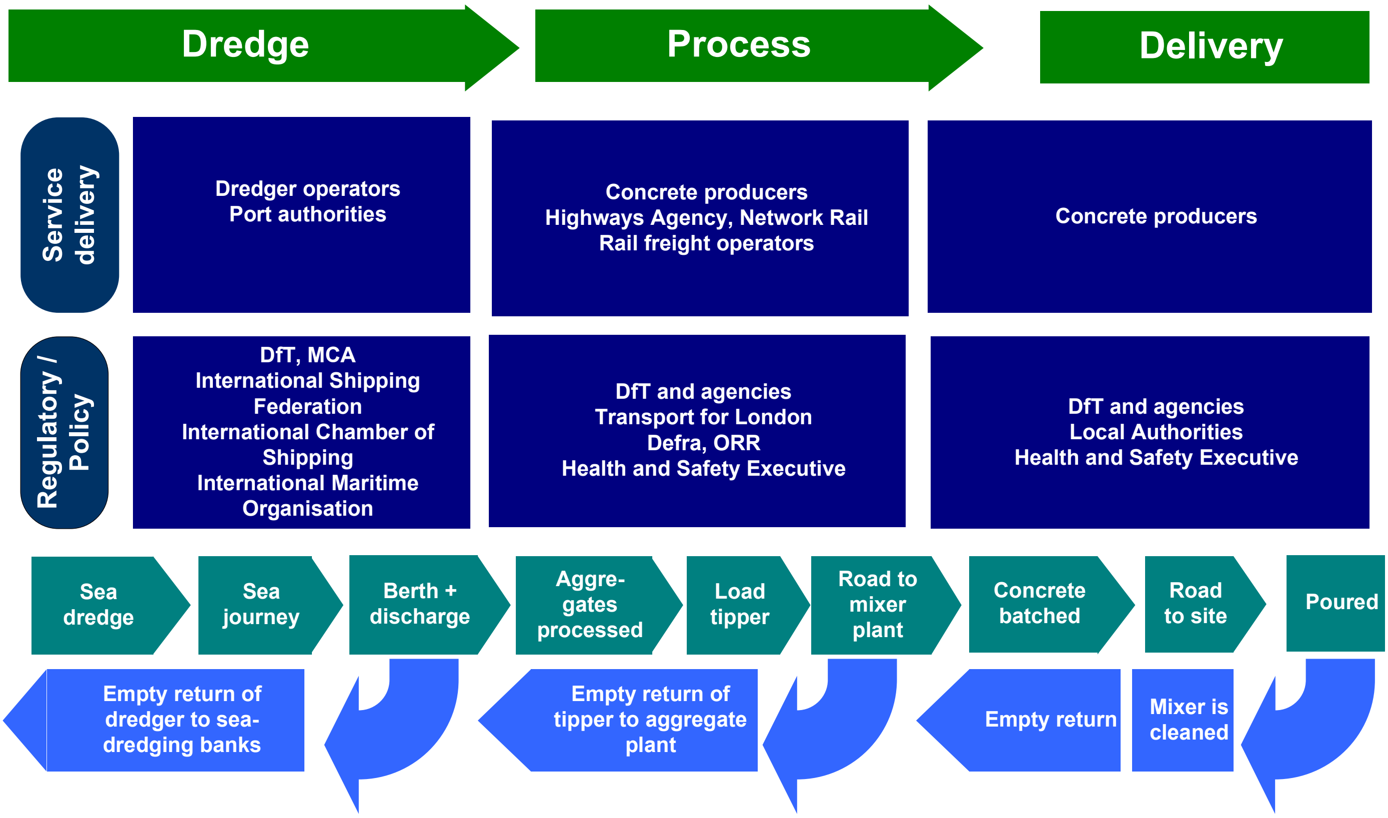
A London client orders 8 cubic metres of concrete (one mixer load) from a concrete producer on a Tuesday afternoon, for a 9am delivery the following day. The delivery location is a construction site in Whitechapel, London.

Courtesy of Cemex

This case study takes each stage of the journey in turn. Figure 4 provides a simplified overview of the end-to-end journey from the dredging of aggregates off the sea floor of the English Channel to the urban delivery of concrete by a rigid concrete mixer. It considers each segment of the journey: what happens, who has responsibility for service delivery and who has a regulatory and policy role.

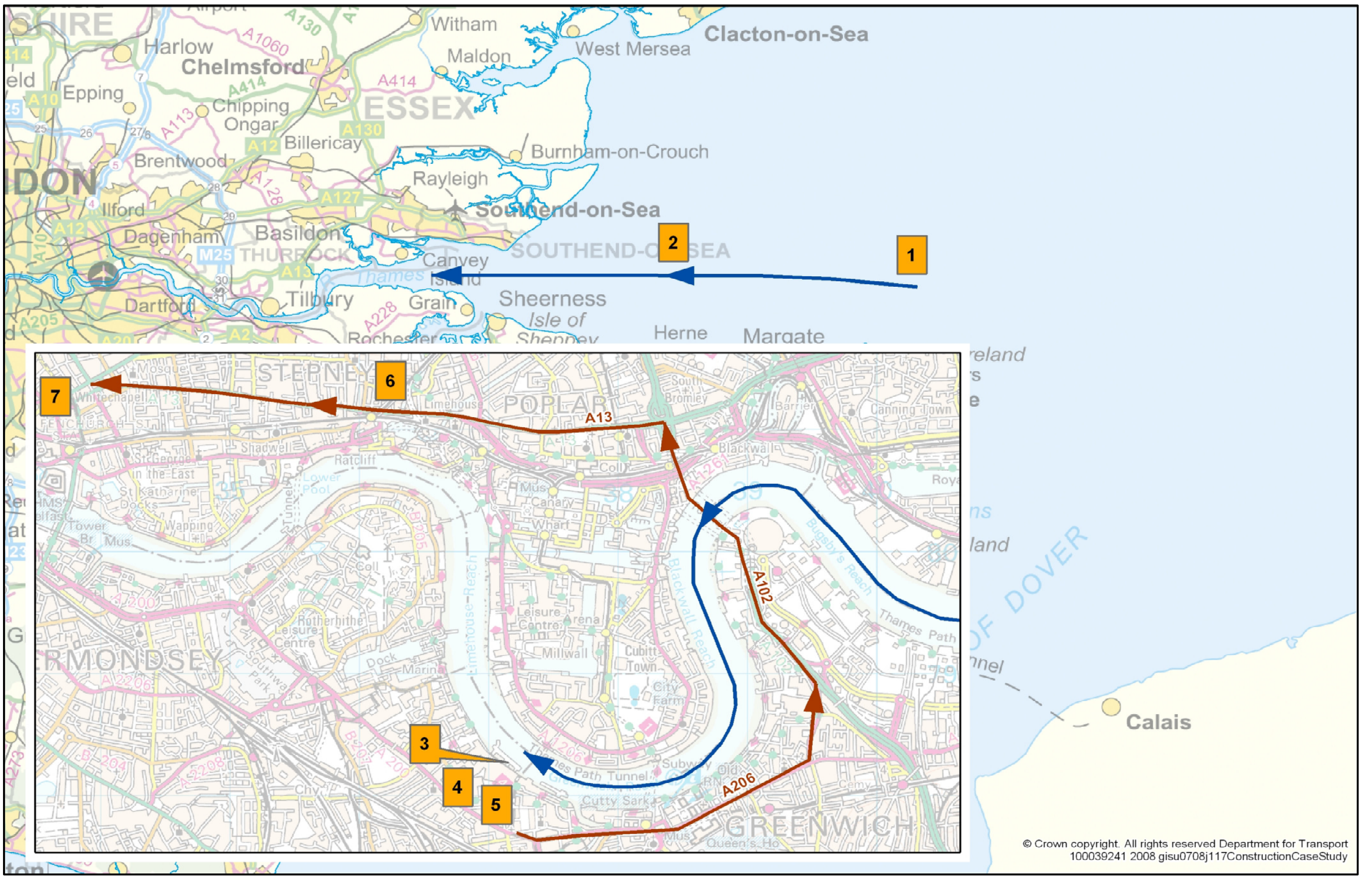
The journey described is a case study only: there are a diverse range of concrete and concrete-related products in the marketplace with different supply chains, modes and business models. For example, the case study follows the movement of aggregates that are sea-dredged, but producers also source aggregates from inland quarries in the UK.

Figure 4: An end-to-end journey of a concrete from dredging to delivery: Diagram



Source: Department for Transport (2008)

Figure 5: An end-to-end journey of a concrete from dredging to delivery: Map



Source: Department for Transport (2008)

Dredging the aggregates

The concrete producer uses a sea-dredger vessel to source the aggregates off sea-dredging banks in the English Channel.

1. Monday A sea dredger commences dredging operations in the Channel. It vacuums the aggregates off the sea floor and up a long tube that feeds directly into the hull of the ship (alternative methods for sea dredging include buckets or "grabs"). The banks are a defined area of land that the producer has paid a licence to remove aggregates from, and while the licensed zone itself doesn't move the sea's tidal movements replenish the aggregate stocks.

Aggregate sea dredger

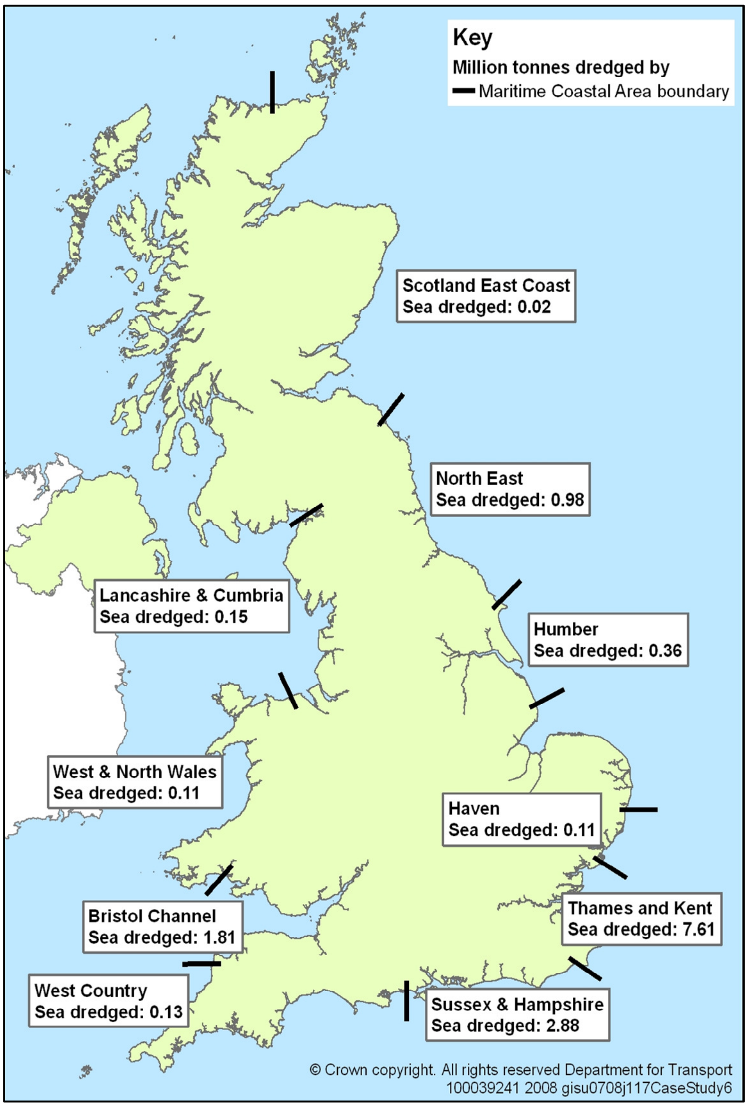
Dredge | Process | Delivery

2. Tuesday The dredger draws 10,000 tonnes of aggregates into the hull of the ship and departs the licensed zone for London. It is part of a fleet operated by the producers and the collection of aggregates in the zone is an almost continual shipping operation. The round trip between zone and port is three days.

3. Wednesday The dredger navigates the Thames utilising the river's tides and arrives at the company-owned wharf at 4am. The wharf is part of an aggregate processing plant and they are positioned close to the population base that requires the concrete but not too far from the source of the aggregate supply. In this example the wharf and processing plant are based at Greenwich on the River Thames.

The aggregates are discharged onto a conveyor belt and into a shore-side hopper where they can then be processed. Up to 30,000 tonnes (or three dredger loads) can be stockpiled at the wharf awaiting processing.

Figure 6: Million tonnes dredged (UK): 2006



Source: Department for Transport (2008)

Sea-Dredging in the UK

Figure 6 maps sea dredged volumes according to Maritime Coastal Area boundaries (areas with sea dredging of less than 0.01 million tonnes are not included). The sea dredging of aggregates does not generally pass through common-user ports, but is fed directly into the supply chain for processing.

The highest volumes of sea dredged aggregates are in the Thames and Kent area (7.61 million tonnes), followed by Sussex and Hampshire (2.88 million tonnes). This is due to the location of major conurbations (and therefore new construction demand) in London and the south east – and the location of quarries providing aggregates and hard rock in the centre and north of England which are more likely to provide aggregate requirements for construction in those areas.

At the Aggregate Processing Plant

4. Wednesday The aggregates are discharged from the hopper into the processing plant where they are washed, screened and graded to produce sand and gravel (they are processed wet to minimise dust). This is a continuous operation and the plant produces 400 tonnes of sand and gravel every hour. On this day the aggregates are discharged directly into the processing plant at 5am and the entire 10,000 tonnes will be processed into sand and gravel by 6am on Thursday.

The sand and gravel is either loaded onto tippers and transported directly to concrete processing plants according to the concrete plant's daily requirements, or it will be stockpiled and then shovelled onto tippers when required.

5. In this case 21 tonnes of sand and gravel are loaded onto a tipper at 6.20am to be transported to the concrete processing plant at Stepney. The tipper will make seven return journeys throughout the day, moving 147 tonnes of sand and gravel.

The tipper departs the Greenwich aggregate processing plant with a full load of sand and gravel at 6.45am on the Wednesday (delivery day).

Courtesy of Cemex

A tipper is a heavy goods vehicle that specialises in dry, bulk good transport of construction materials such as sand, gravel or dirt.

Aggregate Levy Sustainability Fund

A levy of £1.60 per tonne of aggregates (levied prior to grading) is paid to the Aggregate Levy Sustainability Fund, administered by Department for Environment, Food and Rural Affairs (Defra). The purpose of the Fund is fourfold:

1 minimising the demand for primary aggregates,

2 promoting environmentally friendly extraction and transport,

3 addressing the environmental impacts of past aggregates extraction; and

4 compensating local communities for the impacts of aggregates extraction.

Funds are used, for example, to encourage the use of recycled and secondary aggregates and to address the environmental impacts of extraction. The Department for Transport received £936,000 from the fund in 2007 to contribute towards the Safe and Fuel Efficient Driving programme (SAFED) for driver training of aggregate vehicles, and to part fund aggregate mode shift grants.

As the levy is calculated before grading, most processing plants will weigh the aggregates after discharge and before processing.

The processing of aggregates (and, in turn, the concrete mixing) is efficient and relatively fast given the volumes involved. The challenge for concrete producers is transporting the sand and gravel from the processing plant to the concrete plant fast enough to meet demand.

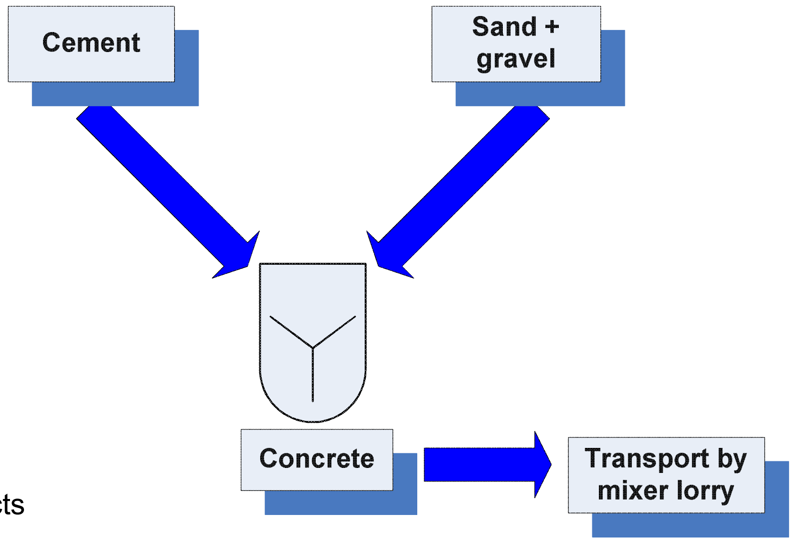
Journey to the concrete processing plant

Wednesday The journey to the concrete processing plant is an urban route and, due to the delivery demands of the plant, the tipper will undertake journeys at both peak and non-peak times on city roads. The tipper travels 8 kms (5 miles) north to the Stepney Concrete Plant: the journey takes 50 minutes at this time of day.

The concrete producer has built-in anticipated congestion on the route to ensure journey reliability, but accidents or unexpected congestion will impact upon planning and journey reliability.

6. 7.35am The tipper arrives at the Stepney Concrete Plant. The driver is expected and he immediately parks the vehicle and tips the load onto a conveyor belt that feeds directly into the mixer. It takes four minutes for the sand and gravel to be mixed with the cement to produce the concrete.

- The plant batches 120 cubic metres of concrete per hour
- Each mixer lorry can be filled with 8 cubic metres (or 15 loads per hour)
- Concrete is mixed per customer requirement and is only produced when an order has been made and a mixer lorry is available to transport it.



The concrete is released through a chute and poured directly into a rotating mixer lorry. The driver inspects the load (two minutes) and collects his ticket for delivery (a further two minutes).

7.50am The mixer departs the Stepney Concrete Plant.

Larger construction sites will shuttle mixers between the concrete mixing plant and the site, or mix their own concrete on the premises. On this day, only one load of pre-mix concrete is required at this site.

Meanwhile, once the the the tipper has released its full load of sand and gravel at the concrete plant it returns to the Aggregate Processing Plant for the next load.

The cement journey

Parallel to the journey of the aggregates, the cement is sourced from a limestone quarry in Derbyshire. Dry bulk cement is transported overnight by rail once a week from Tunstead in the Peak District to Willesden in North London via the West Coast Main Line (the journey takes 6 hours). At Willesden the cement is loaded onto lorries with specialised tankers and transported by road to each of the producer’s concrete plants in London.

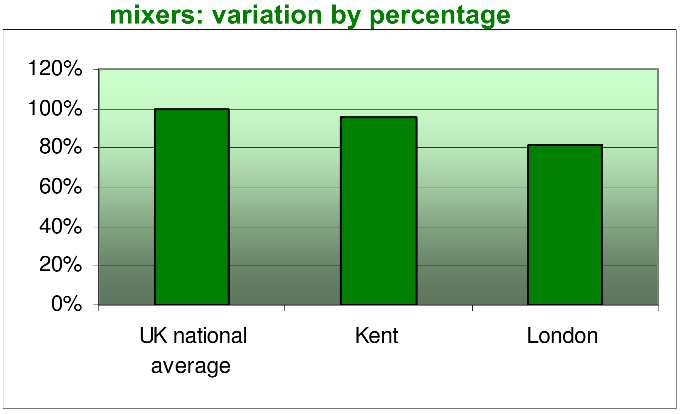
Urban delivery of concrete

7. Wednesday The concrete mixer travels 1.5 kms by road from the Stepney Concrete Plant to the construction site in Whitechapel. The journey takes 55 minutes and the concrete mixer arrives at the construction site at 8.45am. The concrete has arrived 15 minutes early, but additional time has been built into the journey as a buffer against peak hour traffic in the heart of London. This is not an ideal time to make a delivery in central London, but it is the delivery time requested by the client, and if it is delivered late working time is lost on the construction site and any earlier and the site would not be ready for the delivery.

Courtesy of Cemex

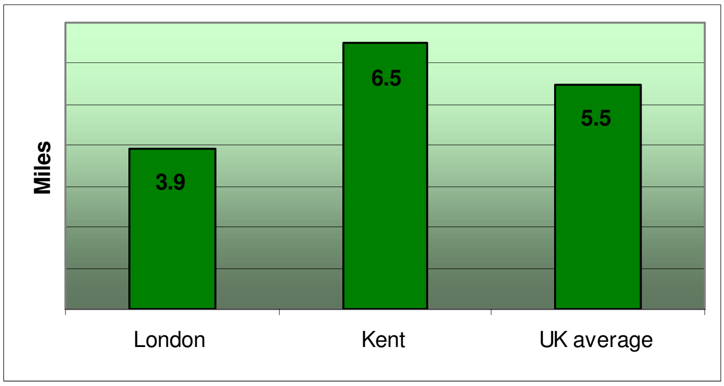
Figure 7 shows in percentage terms the variation in average number of deliveries made by concrete mixers between London, Kent and the rest of the UK. While the daily number of deliveries is commercially sensitive and not detailed, the graph shows that the number of deliveries per vehicle in London is less than the national average; the average distance travelled by concrete mixers in London is significantly less than the UK national average (see Figure 8). This indicates that urban congestion in London is above the national average and the consequence of this for concrete suppliers is that productivity is reduced and drivers are charging higher rates. This, in turn, impacts upon the cost of supply.

Figure 7: number of deliveries made by concrete mixers: variation by percentage



Source: DfT, based on industry data

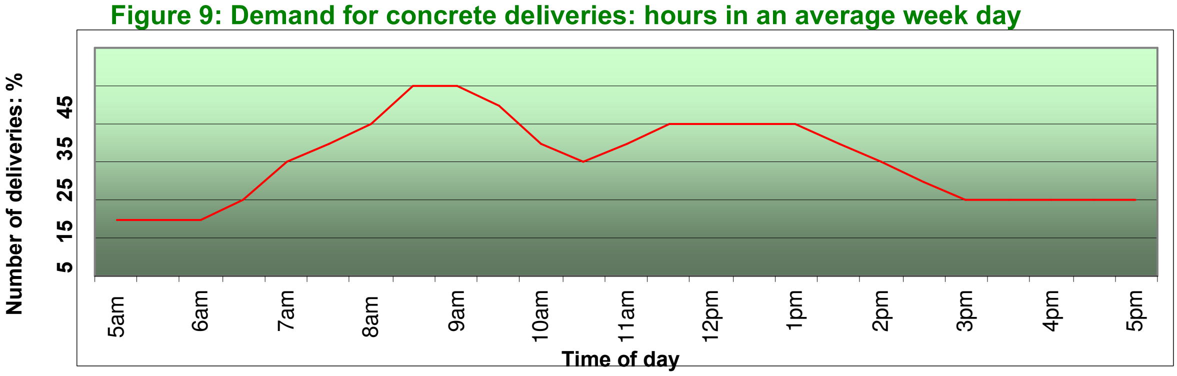
Figure 8: Average concrete mixer journey radial distances: miles



Source: DfT, based on industry data

Figure 9 shows industry trends for the delivery of mixed concrete. There is a peak between 7am and 10am, and 11-am and 1pm. The busiest delivery time overlaps with the morning peak period for congestion. Concrete supply is generally a daylight operation and deliveries, especially during winter, are finished by 3pm.

Figure 9: Demand for concrete deliveries: hours in an average week day



Source: DfT, based on industry data

Dredge | Process | **Delivery**

At the construction site, the driver produces his ticket and the site manager requests that, being early, the driver waits. There is no room on-site, however, and the driver parks the rotating mixer on the road opposite the site.

The site isn't ready for the supply of concrete until 9.20am (20 minutes after scheduled delivery time), and the driver waits 35 minutes to make his delivery. It is now 1.5 hours since the concrete has been mixed and there is only a remaining 30 minutes before the concrete should be poured.

9.20am The site manager instructs the driver to commence unloading the concrete and the mixer is driven into the site and reverses into position. The driver fits the vehicle's chute into position and discharges the concrete.

9.25am The concrete is poured into a trench. The driver backs away and cleans the inside of the vehicle by reversing the rotation of the mixer and washing it out with a hose. This is a health and safety requirement and prevents concrete spillage onto the road.

Within three days the aggregates have been dredged from the English Channel, shipped to London and processed into sand and gravel, transported by tipper to Stepney and mixed with cement to become concrete and delivered and poured at a construction site in Whitechapel.

9.35am The driver returns the empty concrete mixer to Stepney to undertake another job. The return journey takes an hour due to peak traffic conditions. The 20 minute delay at the first site impacts upon delivery times for the rest of the day and the operators will have to rely on efficient transit and delivery times to make up for lost time.

As the end-to-end journey progresses and concrete nears its destination, loads become smaller and transport costs increase: from around 10% of the cost of transporting the aggregates, to 30% of the final delivery cost of the concrete (based on industry estimates).

Other opportunities for vehicle use

Concrete mixers can be used to transport dry aggregates and, in theory, there are opportunities for other uses of concrete mixers. One stakeholder trialled the utilisation of concrete mixers to transport aggregates at night, however the trial was unsuccessful for three reasons:

- The small amounts of aggregates that can be moved by a concrete mixer is uneconomical
- The mixers were not where they were required to be the next morning to perform their core business; and
- It took longer to load and discharge concrete mixers when carrying aggregates.

Construction Consolidation Centres

Construction Consolidation Centres (CCCs) were introduced in London to increase operational efficiency and reduce the number of vehicles that enter into a construction site by consolidating loads outside the congested areas. A CCC was not utilised by the construction site in this case study and they are not an appropriate for concrete mixers which are specialised vehicles and loads. Nonetheless, CCCs are an important response to relieving road congestion in urban areas and is supported by Transport for London and the benefits have been promoted by the Department for Transport under the Freight Best Practice programme.

Stakeholder views

Listening to industry stakeholders in the context of the end-to-end journey we have heard the following from end users in the construction sector:

A diverse end-to-end journey Transport in the construction industry is a mix of long haul bulk movements that are ideal for rail and water transport and short haul, road-based urban deliveries that compete in peak periods of road congestion. The journey of concrete starts with the movement of aggregates and limestone that have large tonnage and longer journeys; through to the mixing and delivery of concrete which is more likely to be road-based and short journeys.

Congestion Relatively fast and reliable journey times are vital in the supply of wet concrete that has a finite life and congestion is therefore planned into scheduled times to minimise delays. The consequence of heavy congestion is that transport operators are factoring it into journey times and this, in turn, reduces vehicle productivity and increases the vehicle fleet. On industry estimates, a 10% increase in congestion results in a 5-8% increase in assets placed on the road (not the full 10% because not all assets are on the road at all times) which, in turn, creates more congestion.

Causes of delay While road congestion can be foreseen and built into journey times (at a productivity cost) stakeholders report that the the longest delays are caused by customers who are not ready to receive their orders; this cannot be planned for and is the most frequently cited reason for delivery delays. Less frequent but also problematic are road conditions that are unforeseen and cannot be factored into journey planning, such as road accidents, unexpected road works and inclement weather.

Competition Custom in the concrete-supply market is determined by price and proximity to the client. The industry relies on having concrete processing plants close to the urban conurbations to ensure market share and the timely delivery of supply to the client. This means that there is an economic and operational advantage in maintaining micro-operations that creates more concrete mixing plants, yet concrete mixers are travelling shorter distances. Further, customers will often not make orders until 24-48 hours before delivery and suppliers need to be responsive to product and delivery requirements, and there is a short lead time between dredging and final delivery.

Supply chain links Tippers are the link in the supply chain between the bulk movement of aggregates by rail and water and the delivery of customised, pre-mix concrete by mixer vehicle. Therefore, while it is necessary for concrete plants to be in close proximity to their customer base, they also need to be located close enough to the aggregate processing plants for tippers to make deliveries of sand and gravel throughout the day. Supply chain links and transport requirements are a key consideration in the location of processing and mixing plants.

Summary

- The supply of concrete relies on multiple and diverse supply chains that have various modes and volumes, depending on the source of materials and the product being moved.
- Larger cities, especially London, are taking longer to deliver wet concrete due to road congestion. Due to the time-critical nature of wet concrete, this results in more concrete plants and more concrete mixers on the road.
- Concrete deliveries times are determined by customers and there are many factors (such as limited daylight hours) that result in deliveries being made during peak road traffic periods.
- Concrete delivery times are determined by customers and the industry experiences peaks between 7am-10am and 11am-1pm daily, and busier days towards the end of the week. The window for making concrete deliveries is even smaller in winter when there is less daylight and more likely to be inclement weather; and these delivery constraints overlay and compete with peak traffic periods.
- The aggregates and limestone/cement are bulk products that lend themselves to rail and water transport; while aggregate processing plants are located close to concrete plants that are linked by short tipper journeys. Likewise, the final delivery of concrete to the customer is generally a short road journey by concrete mixer, however this is offset by the increased greenhouse gas emissions caused by congested traffic.