Proyecto y Construcción de Obras Marítimas

Práctica I: Discusión Técnica

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Planteamiento

Los diques Phoenix fueron una tipología específica de dique en cajón, utilizada durante la Segunda Guerra Mundial como parte de toda la infraestructura destinada al Desembarco de Normandía. El objetivo era poder construir puertos temporales con el fin de facilitar las tareas de suministro a las tropas aliadas.

La tipología en cuestión fue específicamente utilizada en los denominados Puertos de Mulberry, consistentes en un conjunto de diques en cajón construidos en la zona de Arromanches, en la región de Normandía al NO de Francia. Con el paso del tiempo cayeron en desuso y todavía algunos de sus elementos pueden ser observados en la región.

Objetivo

Ante la presión de diversos agentes sociales, económicos y técnicos (gestores gubernamentales, representantes de intereses económicos en sectores de comercio marítimo, hostelería y pesca, observadores de la gestión del medio ambiente y representantes de la comunidad científica y técnica), se abre el debate sobre:

1. La viabilidad para reparar y en su caso ampliar las infraestrcutras Pheonix existentes.
2. Los posibles usos (en caso de que pudiesen satisfacerse varias demandas a la vez) que se podría dar a las estructuras recuperadas.

Discusión

Grupo 1: Gestión.

- Plantear un interés realista en la recuperación de la fiabilidad, funcionalidad y operatividad del proyecto, desde el punto de vista político y de gestión institucional.
- Analizar el conjunto de factores que pueden influir, tanto a favor como en contra, sobre la decisión de recuperación y sus repercusiones.

Nota: en la medida de lo posible, tener en cuenta factores tales como el efecto NIMBY (Not In My BackYard).

Grupo 2: Intereses económicos.

- Analizar los beneficiones que para la economía local y regional podría tener el proyecto de recuperación planteado.

Nota: tener en cuenta posibles factores concernientes a tráfico marítimo, comercio, industria, turismo, pesca, etc.

Grupo 3: Intereses medioambientales.

- Valorar las repercusiones ambientales del proyecto como obra en servicio.
- Discutir y cuantificar en la medida de lo posible, las repercusiones sociales, económicas y ambientales de la reducción o pérdida del servicio prestado por el proyecto.

Nota: se puede hacer un primer tanteo con los índices IRE, ISA, IREO, ISAO.

Grupo 4: Asistencia técnica y científica.

- Delimitar los objetivos de proyecto.
- Discutir la viabilidad técnica del mismo.

Nota: tomar en consideración factores limitantes en términos de clima marítimo y geotécnicos.

Orientación para la preparación del debate

1. El objetivo del debate es justificar las soluciones y propuestas planteadas para la obra marítima desde un punto de vista ténico, pero sin entrar en detalles específicos. Para la realización debería ser suficiente el conocimiento de algunos datos generales concernientes a los diversos enfoques planteados.

2. Se proporciona información relevante relativa a índices de repercusión conforme al criterio de las Recomendaciones de Obras Marítimas (ROM 0.0). Si bien todavía no han sido formalmente introducidos en clase, los contenidos que ahora se presentan son suficientes para una familiarización con su significado, así como para una estimación preliminar en caso de que se considere necesaria.

3. El desarrollo del debate consiste en:

    - Un turno de 5 minutos para presentación de propuestas por parte de cada grupo.
    - Un turno de alegaciones de hasta 5 minutos para cada grupo.
    - Un turno de discusión y conclusiones de hasta 20 minutos en el que todos participan.

4. Es suficiente con la presentación oral de datos y referencias. Se deja al libre criterio de los participantes la preparación de cualquier otro tipo de presentación en un formato específico.

Apéndices: Información Complementaria

A. Carácter de la obra

Con frecuencia el proyecto de una obra marítima se decide a partir de estudios externos previos, en los que se analizan las repercusiones económicas, sociales y ambientales. En función de dichas repercusiones es posible definir los caracteres general y operativo de la obra marítima.

A.1. Carácter general. Índices IRE e ISA

El carácter general de la obra sirve para caracterizar la importancia de un tramo de obra marítima, así como la repercusión económica, social y ambiental en caso de destrucción o pérdida de funcionalidad.
El carácter general se determina considerando un modo principal de fallo adscrito a un estado límite último que proporcione el índice más alto, encontrándose asociado a la seguridad. No obstante, hay casos en los que el carácter se establece en base a un modo principal de fallo adscrito a un estado límite de servicio, y por tanto se encontrará asociado a la funcionalidad.

El carácter general de la obra se determina a través del índice de repercusión económica IRE, y del índice de repercusión social y ambiental ISA:

- El IRE valora cuantitativamente las repercusiones económicas C_{RD} por reconstrucción de la obra, y por cese o afección de las actividades económicas C_{RI} directamente relacionadas con ellas y previsibles en caso de producirse la destrucción o pérdida de la operatividad total de la misma. El IRE se calcula como:

  $$IRE = \frac{C_{RD} + C_{RI}}{C_0} \tag{1}$$

  siendo C_0 un parámetro económico de adimensionalización. En función del valor del IRE las obras marítimas se clasifican conforme a los subintervalos R indicados en la tabla 1.

- El ISA estima cualitativamente el impacto social y ambiental esperable en caso de producirse la destrucción o la pérdida de operatividad total de la obra marítima, valorando la posibilidad y alcance de la pérdida de vidas humanas, daños al medio ambiente y al patrimonio histórico, y alarma social generada, toda vez que el fallo ocurre una vez que las actividades económicas directamente vinculadas a la obra se hallen consolidadas. El ISA se calcula como:

SUBINTERVALO	REPERCUSIÓN ECONÓMICA	IRE
R_1	baja	IRE $\leqslant 5$
R_2	media	$5 <$ IRE $\leqslant 20$
R_3	alta	IRE > 20

Tabla 1: Clasificación de obras marítimas en función del IRE.

$$ISA = \sum_{i=1}^{3} ISA_i \tag{2}$$

en la cual ISA_1 valora la posibilidad y alcance de vidas humanas, ISA_2 valora los daños al medio ambiente y al patrimonio histórico, e ISA_3 valora la alarma social. En función del ISA las obras marítimas se clasifican conforme a los subintervalos S indicados en la tabla 2.

SUBINTERVALO	REPERCUSIÓN SOCIAL	ISA
S_1	sin repercusión	ISA < 5
S_2	baja	$5 \leqslant$ ISA < 20
S_3	media	$20 \leqslant$ ISA < 30
S_4	alta	ISA $\geqslant 20$

Tabla 2: Clasificación de obras marítimas en función del ISA.

A.2. Carácter operativo. Índices IREO e ISAO

El carácter operativo valora las repercusiones económicas y los impactos social y ambiental que se producen cuando una obra marítima deja de estar operativa o reduce el nivel de operatividad.
El carácter operativo de la obra marítima se otorga a todos los tramos cuya reducción o cancelación de la explotación, dé lugar a repercusiones, económicas, sociales y ambientales similares. A los tramos de obra cuya parada operativa implique repercusiones diferentes, se les podrá asigna un carácter específico.

A falta de otra determinación más específica, el carácter operativo de una obra se establece a través del índice de repercusión económica operativo IREO, y del índice de repercusión social y ambiental operativo ISAO:

- El IREO valora cuantitativamente los costes asociados a a la parada operativa de un tramo de obra. En función del valor del IREO las obras marítimas se clasifican según los subintervalos R_O indicados en la tabla 3.

SUBINTERVALO	REPERCUSIÓN ECONÓMICA OPERATIVA	IREO
$R_{O\,1}$	baja	IREO $\leqslant 5$
$R_{O\,2}$	media	$5 <$ IREO $\leqslant 20$
$R_{O\,3}$	alta	IREO > 20

Tabla 3: Clasificación de obras marítimas en función del IREO.

- El ISAO estima de manera cualitativa la repercusión social y ambiental esperable, en caso de producirse un modo de parada operativa de la obra marítima, valorando la posibilidad y alcance de la pérdida de vidas humanas, daños al medio ambiente y al patrimonio histórico, y alarma social generada. El ISAO se calcula como:

$$ISAO = \sum_{i=1}^{3} ISAO_i \tag{3}$$

en la cual $ISAO_1$ valora la posibilidad y alcance de vidas humanas, $ISAO_2$ valora los daños al medio ambiente y al patrimonio histórico, e $ISAO_3$ valora la alarma social. En función del ISAO las obras marítimas se clasifican conforme a los subintervalos S_O indicados en la tabla 4.

En la mayoría de obras marítimas el ISAO es nulo dado que si hubiese impacto ambiental, éste cesaría con la parada operativa. No obstante, en el caso de emisarios submarinos, centrales térmicas, plantas desaladoras, etc., la repercusión por parada operativa puede ser importante, en cuyo caso $ISAO \neq 0$.

SUBINTERVALO	REPERCUSIÓN SOCIAL	ISAO
$S_{O\,1}$	sin repercusión	$\texttt{ISAO} < 5$
$S_{O\,2}$	baja	$5 \leqslant \texttt{ISAO} < 20$
$S_{O\,3}$	media	$20 \leqslant \texttt{ISAO} < 30$
$S_{O\,4}$	alta	$\texttt{ISAO} \geqslant 20$

Tabla 4: Clasificación de obras marítimas en función del ISAO.

B. Cálculo de los índices de repercusión

Corresponde al promotor de la obra marítima ---público o privado---, especificar el carácter del tramo de obra ---caracteres general y operativo de la obra. Cuando no se proporciona una definición específica, el carácter se determinará en función de índices de repercusión cuyos valores se calculan de manera aproximada.

B.1. Cálculo aproximado del IRE

$$IRE = \frac{C_{RD} + C_{RI}}{C_0} \tag{4}$$

- $C_{RD} \rightarrow$ Valora las repercusiones económicas por reconstrucción de la obra. Coste de las obras de reconstrucción a su estado previo. A falta de otros datos se considerarán los costes de construcción inicial, debidamente actualizados.
- $C_{RI} \rightarrow$ Valora las repercusiones económicas por cese o afección de las actividades económicas directamente relacionadas con la obra. Se estima en términos de la pérdida de Valor Añadido Bruto ---VAB---, el cual representa el balance entre entradas y salidas del proceso productivo asociado al conjunto de actividades de la obra, es decir, la diferencia entre la fuerza laboral empleada y los excedentes empresariales generados.
- $C_0 \rightarrow$ Parámetro de adimensionalización. Su valor depende de la estructura económica y nivel de desarrollo económico del país. En España puede considerarse $C_0 \simeq 3 \cdot 10^6$ €.
- A efectos prácticos:

$$\frac{C_{RI}}{C_0} = C(A + B) \tag{5}$$

  - $A \rightarrow$ Cuantifica el ámbito del sistema productivo al cual sirve la obra. Valores: $A = 1$ para ámbito local; $A = 2$ para ámbito regional; $A = 5$ para ámbtio nacional/internacional.
  - $B \rightarrow$ Cuantifica la importancia estratégica del sistema económico y productivo al que sirve la obra. Valores: $B = 0$ para irrelevante; $B = 2$ para relevante; $B = 5$ para esencial.
  - $C \rightarrow$ Cuantifica la importancia dede la obra para el sistema económico y productivo. Valores: $C = 1$ para irrelevante; $C = 2$ para relevante; $A = 5$ para esencial.

B.2. Cálculo aproximado del ISA

$$ISA = \sum_{i=1}^{3} ISA_i \tag{6}$$

- $ISA_1 \rightarrow$ Posibilidad y alcance de pérdida de vidas humanas. Valores: $ISA_1 = 0$ para remota; $ISA_1 = 3$ para baja; $ISA_1 = 10$ para alta; $ISA_1 = 20$ para catastrófica.
- $ISA_2 \rightarrow$ Daños en el medio ambiente y en el patrimonio. Valores: $ISA_2 = 0$ para remoto; $ISA_2 = 2$ para bajo 3; $ISA_2 = 4$ para medio; $ISA_2 = 8$ para alto; $ISA_2 = 15$ para muy alto.
- $ISA_3 \rightarrow$ Alarma social. Valores: $ISA_3 = 0$ para baja; $ISA_3 = 5$ para media; $ISA_3 = 10$ para alta; $ISA_3 = 15$ para máxima.

B.3. Cálculo aproximado del IREO

$$IREO = F(D + E) \tag{7}$$

- $D \rightarrow$ Caracteriza la simultaneidad del periodo de demanda con el periodo de variación de reducción de operatividad. Valores: $D = 0$ para no simultáneo; $D = 5$ para simultáneo.
- $E \rightarrow$ Caracteriza la intensidad de uso de la demanda en el periodo considerado. Valores: $E = 0$ para poco intensivo; $E = 3$ para intensivo; $E = 5$ para muy intensivo.
- $F \rightarrow$ Caracteriza la adaptabilidad de la demanda y del entorno económico a la reducción de operatividad. Valores: $F = 0$ para alta; $F = 1$ para media; $F = 3$ para baja.

B.4. Cálculo aproximado del ISAO

$$ISAO = \sum_{i=1}^{3} ISAO_i \tag{8}$$

- $ISAO_1 \rightarrow$ Posibilidad y alcance de pérdida de vidas humanas. Valores: $ISAO_1 = 0$ para remota; $ISAO_1 = 3$ para baja; $ISAO_1 = 10$ para alta; $ISAO_1 = 20$ para catastrófica.
- $ISAO_2 \rightarrow$ Daños en el medio ambiente y en el patrimonio. Valores: $ISAO_2 = 0$ para remoto; $ISAO_2 = 2$ para bajo 3; $ISAO_2 = 4$ para medio; $ISAO_2 = 8$ para alto; $ISAO_2 = 15$ para muy alto.

- $ISAO_3 \rightarrow$ Alarma social. Valores: $ISAO_3 = 0$ para baja; $ISAO_3 = 5$ para media; $ISAO_3 = 10$ para alta; $ISAO_3 = 15$ para máxima.

B.5. Valores recomendados

A continuación se proporcionan algunos valores recomendados para la vida útil, la probabilidad conjunta de fallo p_f frente a modos principales de fallo adscritos a ELU y ELS, la operatividad r_f y para el número de paradas operativas, todos ellos a partir de los caracteres general y operativo de la obra.

IRE	≤ 5	$6 \sim 20$	> 20
Vida útil	15	25	50

Tabla 5: Vida útil en años.

ISA	< 5	$5 \sim 19$	$20 \sim 29$	≥ 30
$p_{f\,ELU}$	0,20	0,10	0,01	0,0001

Tabla 6: Probabilidad conjunta de fallo frente a ELU.

IREO	≤ 5	$6 \sim 20$	> 20
Operatividad $r_{f\,ELO}$	0,85	0,95	0,99

Tabla 7: Operatividad.

ISAO	< 5	$5 \sim 19$	$20 \sim 29$	≥ 30
Número	10	5	2	0

Tabla 8: Número de paradas operativas.

C. Otros datos de interes relativos al caso de estudio

Coordinates: 50°34′16″N 2°26′34″W

Phoenix breakwaters

From Wikipedia, the free encyclopedia

A line of Phoenix elements forming a breakwater at Arromanches

The **Phoenix** breakwaters were a set of reinforced concrete caissons built as part of the artificial Mulberry harbours that were assembled as part of the follow-up to the Normandy landings during World War II. They were constructed by civil engineering contractors around the coast of Britain. They were collected at Dungeness and Selsey, and then towed across the English Channel and sunk to form the Mulberry harbour breakwaters replacing the initial 'Gooseberry' block ships.[1] Further caisson were added in the autumn of 1944 to re-enforce the existing structure to cope with the harbour continuing in use longer than planned.[1]

A pair of Phoenixes at Portland Harbour

Several Phoenix breakwaters are still in use in Britain: two are part of the harbour off Castletown at Portland Harbour and two can be dived in less than 10 metres of water off Pagham. There is also a smaller Phoenix Caisson (type C) in Langstone Harbour.[1]

A wrecked Phoenix breakwater is also to be seen, broken in two, in the Thames estuary off Shoeburyness in Essex. It broke while being towed from Harwich in June 1944. To avoid it causing a hazard to shipping in the Thames estuary, it was beached on the mud on the northern edge of the Thames dredged shipping channel. It is about a mile from the beach. It is not quite covered at high tide, but it is topped by a beacon to warn shipping of its presence.

It makes an interesting destination for a walk at low tide. The hole it has gouged in the mud around it can be used as a swimming pool, where reckless youngsters can use the Phoenix itself as a diving platform. Many unfamiliar with the mudflats have been trapped by the tide and the confusing, changeable channels and have had to be rescued by the nearby RNLI station.

Four Phoenix breakwaters were used in the Netherlands to plug a gap in the dyke at Ouwerkerk after the North Sea Flood of 1953. They have now been converted into a museum for the floods called the Watersnoodmuseum. You can walk through the four caissons.

See also

- Mulberry harbour

References

1. Hughes, Michael; Momber, Gary (2000). "The Mulberry Harbour Remains". In Allen, Michael J; Gardiner, Julie. *Our Changing Coast a survey of the intertidal archaeology of Langstone Harbour Hampshire*. York: Council for British Archaeology. pp. 127–128. ISBN 1-902771-14-1.

Wikimedia Commons has media related to ***Phoenix breakwaters***.

- The Mulberry Harbour Units, Portland, Dorset (http://www.geoffkirby.co.uk/Portland/685740/).
- The Watersnoodmuseum, Ouwerkerk, The Netherlands (http://www.watersnoodmuseum.nl/en_GB/).

Categories: Breakwaters | Operation Neptune | Buildings and structures in England

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Coordinates: 49.3475°N 0.6340°W

Mulberry harbour

From Wikipedia, the free encyclopedia

Mulberry harbours were temporary portable harbours developed by the British during World War II to facilitate the rapid offloading of cargo onto beaches during the Allied invasion of Normandy in June 1944. After the Allies successfully held beachheads following D-Day, two prefabricated harbours were taken in sections across the English Channel from Britain with the invading army and assembled off Omaha (Mulberry "A") and Gold Beach (Mulberry "B").[1][2]

View of the Mulberry B harbour "Port Winston" at Arromanches in September 1944

The Mulberry harbours were to be used until the Allies could capture a French port, initially thought to be around three months. However, it was not until six months after D-Day that the Belgian port of Antwerp was captured that use of the harbour at Gold Beach lessened. It was used for 10 months after D-Day and over 2.5 million men, 500,000 vehicles, and 4 million tonnes of supplies were landed using it before it was fully decommissioned. The Mulberry harbour at Omaha Beach had been severely damaged in a storm in late June 1944 and was abandoned.

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Background

The Dieppe Raid of 1942 had shown that the Allies could not rely on being able to penetrate the Atlantic Wall to capture a port on the north French coast. The problem was that large ocean-going ships of the type needed to transport heavy and bulky cargoes and stores needed sufficient depth of water under their keels, together with dockside cranes, to off-load their cargo and this was not available except at the already heavily-defended French harbours. Thus, the Mulberries were created to provide the port facilities necessary to offload the thousands of men and vehicles, and tons of supplies necessary to sustain Operation Overlord and the Battle of Normandy. The harbours were made up of all the elements one would expect of any harbour: breakwater, piers, roadways etc.

Design and development

An early idea for temporary harbours was sketched by Winston Churchill in a 1917 memo to Lloyd George. This memo was for artificial harbours to be created off the German islands of Borkum and Sylt. No further investigation was made and the memo was filed away.[3] In 1940 the civil engineer Guy Maunsell wrote to the War Office with a proposal for an artificial harbour, but the idea was not at first adopted.[4]

Winston Churchill issued his famous memo 'Piers for use on beaches' on 30 May 1942, apparently in some frustration at the lack of progress being made on finding a solution to the temporary harbour problem.[5] Between June 17 to August 6, 1942, Hugh Iorys Hughes submitted a design concept for artificial harbours to the War Office.[6]

At a meeting following the Dieppe Raid of 19 August 1942, Vice-Admiral John Hughes-Hallett (the naval commander for the Dieppe Raid) declared that if a port could not be captured, then one should be taken across the Channel. Hughes-Hallett had the support of Churchill. The concept of Mulberry harbours began to take shape when Hughes-Hallett moved to be Naval Chief of Staff to the Overlord planners.


Aerial view of Mulberry harbour "B" (October 27, 1944)

In the autumn of 1942, the Chief of Combined Operations Vice-Admiral Lord Louis Montbatten, outlined the requirement for piers at least a mile long at which a continuous stream of supplies could be handled, including a pier head capable of handling 2,000-ton ships.

Trials

In 1943 a trial of three competing designs for the cargo-handling jetties was set up:

- Hugh Iorys Hughes (a civil engineer) who developed his "Hippo" piers and "Crocodile" bridge spans;
- Ronald Hamilton (working at the Department of Miscellaneous Weapons Development) who devised the "Swiss Roll" which consisted of a floating roadway made of waterproofed canvas stiffened with slats and tensioned by cables;
- Lieutenant Colonel William T Everall and Major Allan Beckett (of the War Office's 'Transportation 5 Department' (Tn5)) who designed a floating bridge linked to a pier head (the latter had integral 'spud' legs that were raised and lowered with the tide).

Prototypes of each of the designs were built and tested at Rigg Bay on the Solway Firth. The tests revealed various problems (the "Swiss Roll" would only take a maximum of a 7-ton truck in the Atlantic swell). However the final choice of design was determined by a storm during which the "Hippos" were undermined causing the "Crocodile" bridge spans to fail and the Swiss Roll was washed away. Tn5's design proved the most successful and Beckett's floating roadway (subsequently codenamed 'Whale') survived undamaged; the design was adopted and 10 mi (16 km) of Whale roadway were manufactured under the management of J. D. Bernal and Brigadier Bruce White, the Director of Ports and Inland Water Transport at the War Office.

Preparation

With the planning of Operation Overlord at an advanced stage by the summer of 1943, it was accepted that the proposed artificial harbours would need to be prefabricated on the UK and then towed across the English Channel.

The need for two separate artificial harbours - one American and one British/Canadian - was agreed at the Quebec Conference in August 1943. An Artificial Harbours Sub-Committee was set up under the Chairmanship of the civil engineer Colin R White (Sir Bruce White's brother) to advise on the location of the harbour and the form of the breakwater; the Sub-Committee's first meeting was held at the Institution of

Civil Engineers (ICE) on 4 August 1943.[7] The minutes of the Sub-Committee's meetings show that initially it was envisaged that bubble breakwaters would be used, then block ships were proposed and finally, due to an insufficient number of block ships being available, a mix of block ships and purpose made concrete caisson units.

On 2 September 1943 the Combined Chiefs of Staff estimated that the artificial ports (Mulberries) would need to handle 12,000 tons per day, exclusive of motor transport and in all weathers. On 4 September the go ahead was given to start work immediately on the harbours. However, infighting between the War Office and the Admiralty over responsibility was only resolved on 15 December 1943 by the intervention of the Vice-Chiefs of Staff. The decision was that the Admiralty managed the blockships, Bombardons and assemble of all constituent parts on the south coast of England. Further the Admiralty would undertake all necessary work to survey, site, tow and mark navigation.

The War Office was given the task of constructing the concrete caisson (Phoenixes), the roadways (Whales) and protection via anti-aircraft installations. Once at the site, the army was responsible for sinking the caissons and assembling all the various other units of the harbours.

For the Mulberry A at Omaha Beach, the naval Corps of Civil Engineers would construct the harbour from the prefabricated parts.

The proposed harbours called for many huge caissons of various sorts to build breakwaters and piers and connecting structures to provide the roadways. The caissons were built at a number of locations, mainly existing ship building facilities or large beaches like Conwy Morfa around the British coast. The works were let out to commercial construction firms including Balfour Beatty, Henry Boot, Bovis & Co, Cochrane & Sons, Costain, Cubitts, French, Holloway Brothers, John Laing & Son, Peter Lind & Company, Sir Robert McAlpine, Melville Dundas & Whitson, Mowlem, Nuttall, Parkinson, Pauling & Co. and Taylor Woodrow.[8] On completion they were towed across the English Channel by tugs[9] to the Normandy coast at only 4.3 Knots (8 km/h or 5 mph), built, operated and maintained by the Corps of Royal Engineers, under the guidance of Reginald D. Gwyther, who was appointed CBE for his efforts.

Beach surveys

Both locations for the temporary harbours required detailed information concerning geology, hydrography and sea conditions. To collect this data a special team of hydrographers were created in October 1943. The 712th Survey Flotilla, operated from naval base HMS *Tormentor* in Hamble, were detailed to collect soundings off the enemy coast. Between November 1943 and January 1944 this team used a Landing Craft Personnel (Large), or LCP(L), to survey the Normandy coast.

The special LCP(L) was manned by a Royal Navy crew and a small group of hydrographers. The first sortie, Operation KJF, occurred on the night of 26/27 November 1943 when three LCP(L)s took measurements off the port of Arromanches, the location for Mulberry B. A follow up mission, Operation KJG, to the proposed location for Mulberry A happened on December 1/2 but a navigation failure meant the team sounded an area 2,250 yards west of the correct area.

Two attempts had to be made to take soundings off the Point de Ver. The first sortie, Operation Bellpush Able, on December 25/26 had issues with their equipment and returned on December 28/29 to complete the task.

On New Year's Eve 1943, a Combined Operations Pilotage Party (COPP), left Gosport for the Gold Beach area at Luc-sur-Mer. Two soldiers of the Royal Engineers, Major Scott-Bowden and Sergeant Ogden-Smith, were landed on the beach at night in Operation Postage Able and took samples of the sand. These were crucial in determining whether the armoured vehicles would be able to operate on the beach or become bogged down. The final survey, Operation Bellpush Charlie, occurred on the night of January 30/31, but limited information was gathered due to fog and German lookouts heard the craft. Further sorties were abandoned.[10]

Deployment

On the afternoon of 6 June 1944 (D-Day) over 400 towed component parts (weighing approximately 1.5 million tons) set sail to create the two Mulberry harbours. It included all the blockships (codenamed Corncobs) to create the outer breakwater (Gooseberries) and 146 concrete caissons (Phoenixes).


Wrecked pontoon causeway of one of the "Mulberry" artificial harbours, following the storm of 19–22 June 1944.

Arromanches Mulberry

At Arromanches, the first Phoenix was sunk at dawn on 9 June 1944. By 15 June a further 115 had been sunk to create a five-mile-long arc between Tracy-sur-Mer in the west to Asnelles in the east. To protect the new anchorage, the superstructures of the blockships (which remained above sea-level) and the concrete caissons were festooned with anti-aircraft guns and barrage balloons.

Omaha Mulberry

Arriving first on D-Day itself were the Bombardons followed a day later by the first blockship. The first Phoenix was sunk on 9 June and the Gooseberry was finished by 11 June. By 18 June two piers and four pier heads were working. Though this harbour was abandoned in late June (see below), the beach continued to be used for landing vehicles and stores using Landing Ship Tanks (LSTs). Using this method, the Americans were able to unload a higher tonnage of supplies than at Arromanches. Salvageable parts of the artificial port were sent to Arromanches to repair the Mulberry there.[11]

The storm of 19 June 1944

Both harbours were almost fully functional when on 19 June a large north-east storm at Force 6 to 8 blew into Normandy and devastated the Mulberry harbour at Omaha Beach. The harbours had been designed with summer weather conditions in mind but this was the worst storm to hit the Normandy coast in 40 years.

The destruction at Omaha was so bad that the entire harbour was deemed irreparable. 21 of the 28 Phoenix caisson were completely destroyed and the Bombardons were cast adrift and the roadways and piers smashed.

At Arromanches, the Mulberry there was more protected, and although damaged it remained intact. This surviving Mulberry "B" came to be known as **Port Winston**. While the harbour at Omaha was destroyed sooner than expected, Port Winston saw heavy use for eight months, despite being designed to last only three months. In the 10 months after D-Day, it was used to land over 2.5 million men, 500,000 vehicles, and 4 million tonnes of supplies providing much needed reinforcements in France.[12] In response to this longer than planned use the Phoenix breakwater was reinforced with the addition of specially strengthened caisson.[13]

The Royal Engineers had built a complete Mulberry Harbour out of 600,000 tons of concrete between 33 jetties, and had 10 mi (16 km) of floating roadways to land men and vehicles on the beach. Port Winston is commonly upheld as one of the best examples of military engineering. Its remains are still visible today from the beaches at Arromanches.

Harbour elements and code names

Below are listed brief details of the major elements of the harbours together with their associated military code names.

Mulberry

Mulberry was the codename for all the various different structures that would create the artificial harbours. These were the "Gooseberries" which metamorphosed into fully fledged harbours. There were two harbours, Mulberry "A" and Mulberry "B". The "Mulberry" harbours consisted of a floating outer breakwater called "Bombardons", a static breakwater consisting of "Corncobs" and reinforced concrete caissons called "Phoenix", floating piers or roadways codenamed "Whales" and ""Beetles" and pier heads codenamed "Spuds". These harbours were both of a similar size to Dover harbour. In the planning of Operation Neptune the term Mulberry "B" was defined as, "An artificial harbour to be built in England and towed to the British beaches at Arromanches."[14]

The remains of the harbour off Arromanches in 1990

Mulberry "A"

The Mulberry harbour assembled on Omaha Beach at Saint-Laurent-sur-Mer was for use by the American invasion forces. Mulberry "A" (American) was not securely anchored to the sea bed as Mulberry "B" had been by the British, resulting in such severe damage during the Channel storms of late June 1944 that it was considered to be irreparable and its further assembly ceased.[15] It was commanded by Augustus Dayton Clark.

Mulberry "B"

Mulberry "B" (British) was the harbour assembled on Gold Beach at Arromanches for use by the British and Canadian invasion forces. The harbour was unofficially named "Port Winston"[16] and was decommissioned six months after D-Day as allied forces were able to use the recently captured port of Antwerp to offload troops and supplies.

Breakwaters

Corncobs and Gooseberries (block ships)

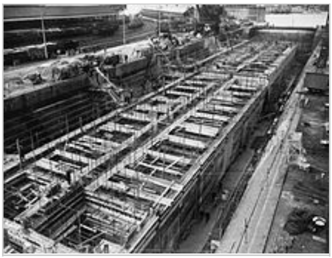
Corncobs were block ships that crossed the English Channel either under their own steam or that were towed and then scuttled to create sheltered water at the five landing beaches. Once in position the *Corncobs* created the sheltered waters known as *Gooseberries*.

The ships used for each beach were:

- Utah Beach (Gooseberry 1): *Benjamin Contee*, *David O. Saylor*, *George S. Wasson*, *Matt W. Ransom*,[17] *West Cheswald*, *West Honaker*, *West Nohno*, *Willis A. Slater*, *Victory Sword* and *Vitruvius*.
- Omaha Beach (Gooseberry 2): *Artemas Ward*,[17] *Audacious*, *Baialoide*, HMS *Centurion*, *Courageous*, *Flight-Command*, *Galveston*, *George W. Childs*, *James W. Marshall*, *James Iredell*,[17] *Illinoian*,[18][19] *Olambala*, *Potter*, *West Grama* and *Wilscox*.
- Gold Beach (Gooseberry 3): *Alynbank*, *Alghios Spyridon*, *Elswick Park*, *Flowergate*, *Giorgios P.*, *Ingman*, *Innerton*, *Lynghaug*, *Modlin*, *Njegos*, *Parkhaven*, *Parklaan*, *Saltersgate*, *Sirehei*, *Vinlake* and *Winha*.
- Juno Beach (Gooseberry 4): *Belgique*, *Bendoran*, *Empire Bunting*, *Empire Flamingo*, *Empire Moorhen*, *Empire Waterhen*, *Formigny*, *Manchester Spinner*, *Mariposa*, *Panos* and *Vera Radcliffe*.
- Sword Beach (Gooseberry 5): *Becheville*, *Courbet*, *Dover Hill*, HMS *Durban*, *Empire Defiance*, *Empire Tamar*, *Empire Tana*, *Forbin* and HNLMS *Sumatra*.

Two of the "Gooseberries" grew into "Mulberries", the artificial harbours.[20]"

Phoenix caissons


Phoenix construction, Weymouth 1944

Phoenixes were reinforced concrete caissons constructed by civil engineering contractors around the coast of Britain, collected and sunk at Dungeness and Pagham prior to D-Day. There were six different sizes of caisson (from approximately 2,000 tons to 6,000 tons each) and each unit was towed to Normandy by two tugs at around three knots. The caissons were initially sunk awaiting D-Day and then engineers refloated ("resurrected", hence the name) the Phoenixes and US Navy Captain (later Rear Admiral) Edward Ellsberg, already well known for quickly refloating scuttled ships at Massawa and Oran, was brought in to accomplish the task, though not without obtaining Churchill's intervention in taking the task away from the Royal Engineers and giving it to the Royal Navy. The Phoenixes, once refloated, were towed across the channel to form the "Mulberry" harbour breakwaters together with the "Gooseberry" block ships. Ellsberg rode one of the concrete caissons to Normandy; once there he helped unsnarl wrecked landing craft and vehicles on the beach.[21]

Bombardons


A pair of Phoenixes, and the remains of a third, at Arromanches

The *Bombardons* were large 200 ft (61 m) by 25 ft (7.6 m) cross-shaped floating breakwaters fabricated in steel that were anchored outside the main breakwaters that consisted of Gooseberries (block ships) and Phoenixes (concrete caissons). 24 bombardon units, attached to one another with hemp ropes, would create a 1 mi (1.6 km) breakwater. During the storms at the end of June 1944 some Bombardons broke up and sank while others parted their anchors and drifted down onto the harbours, possibly causing more damage to the harbours than the storm itself. The design of the

Bombardons was the responsibility of the Royal Navy while the Royal Engineers were responsible for the design of the rest of the Mulberry harbour equipment.

Roadways

Whales

The dock piers were code named *Whales*. These piers were the floating roadways that connected the "Spud" pier heads to the land. Designed by Allan Beckett the roadways were made from innovative torsionally flexible bridging units that had a span of 80 ft., mounted on pontoon units of either steel or concrete called "Beetles".[22] After the war many of the "Whale" bridge spans from Arromanches were used to repair bombed bridges in France, Belgium and the Netherlands. Such units are still visible as a bridge over the Meuse River in Vacherauville (Meuse), as a bridge over the Moselle River on road D56 between Cattenom and Kœnigsmacker (Moselle) and in Vierville-sur-Mer (Calvados) along road D517. A Whale span from Mulberry B that was reused after the war at Pont-Farcy was saved from destruction in 2008 by *Les Amis du Pont Bailey*, a group of English and French volunteers. Seeking a permanent home for the Whale span the group gifted it to the Imperial War Museum and it was returned to England in July 2015. After conservation work the span now features as part of the Land Warfare exhibition at Imperial War Museum Duxford.


A Whale floating roadway leading to a Spud pier at Mulberry A off Omaha Beach

Beetles

Beetles were pontoons that supported the *Whale* piers. They were moored in position using wires attached to "Kite" anchors which were also designed by Allan Beckett. These anchors had such high holding power that very few could be recovered at the end of the War. The Navy was dismissive of Beckett's claims for his anchor's holding ability so Kite anchors were not used for mooring the bombardons. The only known surviving Kite anchor is displayed in a private museum at Vierville-sur-Mer although a full size replica forms part of a memorial to Beckett in Arromanches.

Spud Piers

The pier heads or landing wharves at which ships were unloaded. Each of these consisted of a pontoon with four legs that rested on the sea bed to anchor the pontoon, yet allowed it to float up and down freely with the tide.

Surviving remnants in the UK

Sections of Phoenix caission can be found at:

- Thorpe Bay, Southend-on-Sea – whilst being towed from Immingham to Southsea, the caisson began to leak and was intentionally beached on a sandbank in the Thames Estuary. It is accessible at low tide.[23][24]
- Pagham, West Sussex – known as The Far Mulberry, it sank off the coast, settled and cracked and is now lying at about 10 m (33 ft) underwater.[25]

- Littlestone-on-Sea, Kent – caisson could not be refloated.[26]
- Langstone Harbour, Hayling Island – faulty caisson left in-situ at place of construction.[27]
- Portland Harbour, Portland, Dorset – two can be seen from the beach at Castletown

German equivalent of Mulberry

In the period between postponement and cancellation of Operation Sea Lion, the invasion of the UK, Germany developed some prototype prefabricated jetties with a similar purpose in mind.[28] These could be seen in Alderney, until they were demolished in 1978.[28] The remaining foundations for the Alderney jetty formed an obstruction to the commercial quay extension project carried out in 2008-2009.

Littlestone-on-Sea Phoenix caisson

Daily Telegraph crosswords

"Mulberry" and the names of all the beaches were words appearing in the *Daily Telegraph* crossword puzzle in the month prior to the invasion. The crossword compilers, Melville Jones[29] and Leonard Dawe, were questioned by MI5 who determined the appearance of the words was innocent, but over sixty years later, a former student reported that Dawe frequently requested words from his students, many of whom were children in the same area as US military personnel.[30]

Deception

Some troops from the American Ghost Army went to Normandy two weeks after D-Day to simulate a fake Mulberry harbour. The deception was created in such a way that at night its lights drew German gunfire away from the real Mulberries.

See also

- Operation Pluto
- *Lily*: a floating airstrip using components developed for the Mulberry harbour.

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External links

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- *D-Day's Sunken Secrets*, PBS *Nova* program originally aired May 28, 2014, pertinent segment runs from approx. 1 hr., 35 min. mark through 1 hr. 45 min. mark (http://www.pbs.org/wgbh/nova/military/dday-sunken-secrets.html)

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