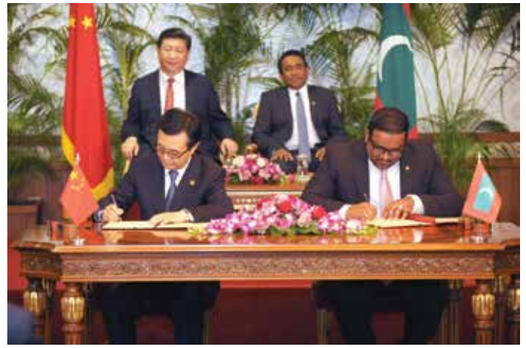
The Preliminaries
准备工作

A number of steps were required before the vision of the bridge could be realized. Although there had been previous discussions with the Chinese Government earlier by the previous president, what set the ball rolling was the visit of HE Xi Jinping on the invitation of Preident Yameen, and the signing of a memorandum to promote the bridge. The agreement was signed by the Minister of Tourism of Maldives, Hon. Ahmed Adeeb Abdul Gafoor, and the Chinese Minister of Commerce, Hon. Gao Hucheng. The date was 15th September 2014.

Other steps towards realizing the first bridge in the Maldives include the feasibility study to establish whether a bridge is possible, geotechnical survey of the seabed and the floating of tenders for the design and construction. These steps are usually involved in any large construction project.



Following the signing of the agreement on 15th September 2014, a flurry of activity started. Initially, there was a number of feasibility studies. A team of eight Chinese members were conducting a feasibility study in October 2014. An agreement was signed on 1st December 2014 for another preliminary feasibility study.

Some 19 prequalified Chinese companies expressed interest in building the bridge However, only three companies submitted the bids. The newspaper date for the opening was 11th November 2015. Bid opening was held in China. The three companies which submitted the bids were China Railway Major Bridge Engineering Group Co., Ltd., CCCC Second Harbour Engineering Company Ltd. and Sichuan Road and Bridge Construction (Group) Corp. Ltd, according to local papers.

大约19家经过资格预审的中国公司表示对本项目感兴趣。然而，只有三家公司投标。 开标仪式定在2015年11月11日，在中国举行。据当地媒体报道，投标的三家公司分别是中铁大桥局集团有限公司、中交第二航务工程局有限公司和四川路桥建设集团股份有限公司。

For the bridge design, 29 bore holes some 30–75 metres deep were drilled. The initial borehole was drilled in the presence of government officials on 20th May 2015.

根据大桥设计，需钻29个约30-75米深的钻孔。2015年5月20日在政府官员见证下钻探首个钻孔。

The final design of the bridge was unveiled at an outdoor event held near bridge site in the evening of 8th September 2015. Many officials were present. Finally, the bridge vision has a relatable image.

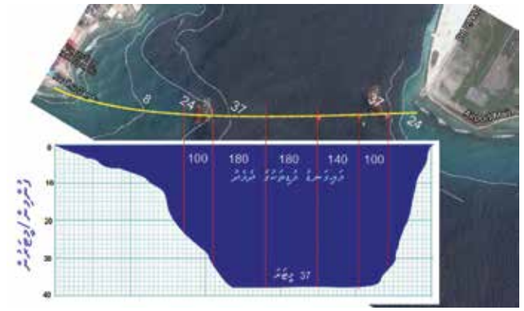
2015年9月8日晚，在桥址附近举办的户外活动上揭示了大桥最终方案设计，大桥形象跃然眼前。当时许多官员出席该活动。

On 30th December 2015, the contract was signed at Dharubaaruge with the selected project contractor. The contractor was CCCC Second Harbour Engineering Company Ltd.

2015年12月30日，在Dharubaaruge与选定的项目承包商，即中交第二航务工程局有限公司，签订合同。

Decades ago, a small island, called Gaadhoo, on the eastern side of Hulhulé was reclaimed to make the airport runway longer. The channel or strait between Hulhulé and Malé has a depth of about 46 metres at the deepest point along the proposed bridge line. Merchant ships sail to Malé harbour through this channel which opens to the Indian Ocean; the gateway to the channel from the Ocean is called Gaadhoo Kolhu. After building the bridge, merchant ships have to be diverted to another opening in the outer atoll reef to gain access to the harbour.

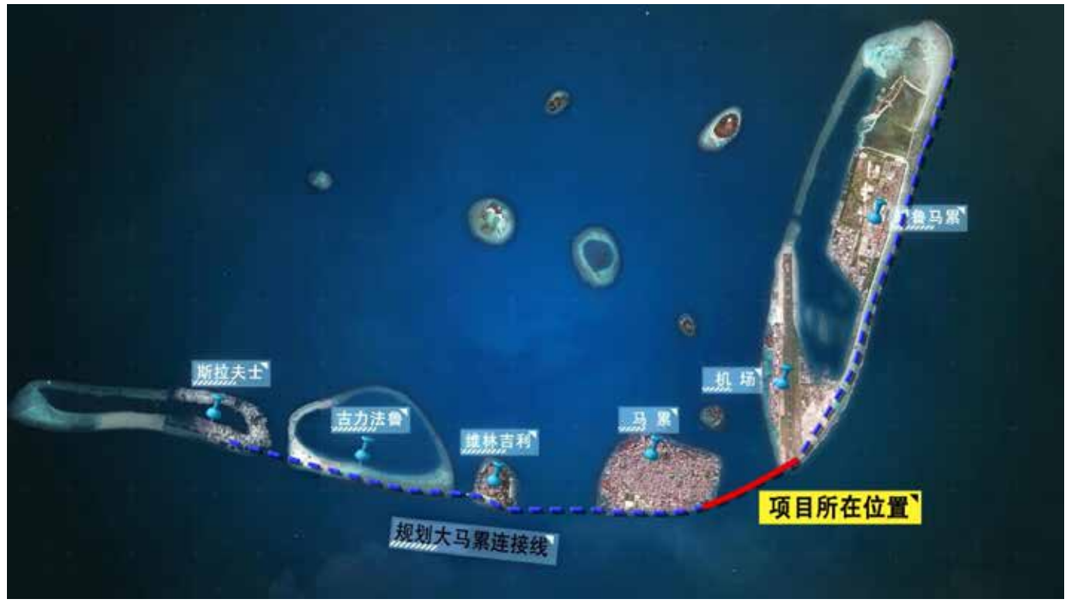
The opposite page shows a contour map of the depth of the channel. The bridge was built along the shallower areas. However, as the image on the right shows, both sides fall rather steeply to the flat middle section of the strait.

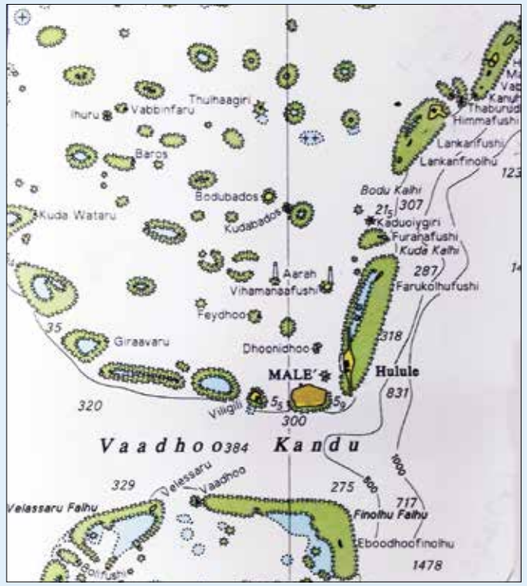


左页显示了航道深度的等高线图。大桥沿较浅区域建立。然而，正如右图所示，海峡两侧较其中间部分更为陡峭。

The China-Maldives Friendship Bridge is the first bridge to be built in the Maldives. Witnessing a bridge being built and used for development imprint in the minds of the people what could be achieved. Therefore, the bridge has opened the minds of the people to endless possibilities. The same transformation of thinking took place when shallow lagoons were reclaimed by modern suction hopper dredges in a matter of days. People realized that other nearby islands could also be connected by bridges.

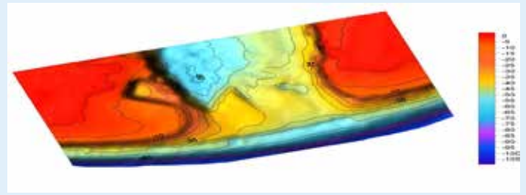
中马友谊大桥是马尔代夫的第一座大桥。大桥将促进国家发展，人们见证了它的建造过程，这在他们心中留下了目标可以实现的印象。因此，这座桥梁开启了人们对无限可能的想象。当用吸料斗挖泥机在几天内就把浅水泻湖填埋时，人们的思维也发生了同样的转变。大家意识到也可以通过桥梁把附近其他岛屿连接起来。

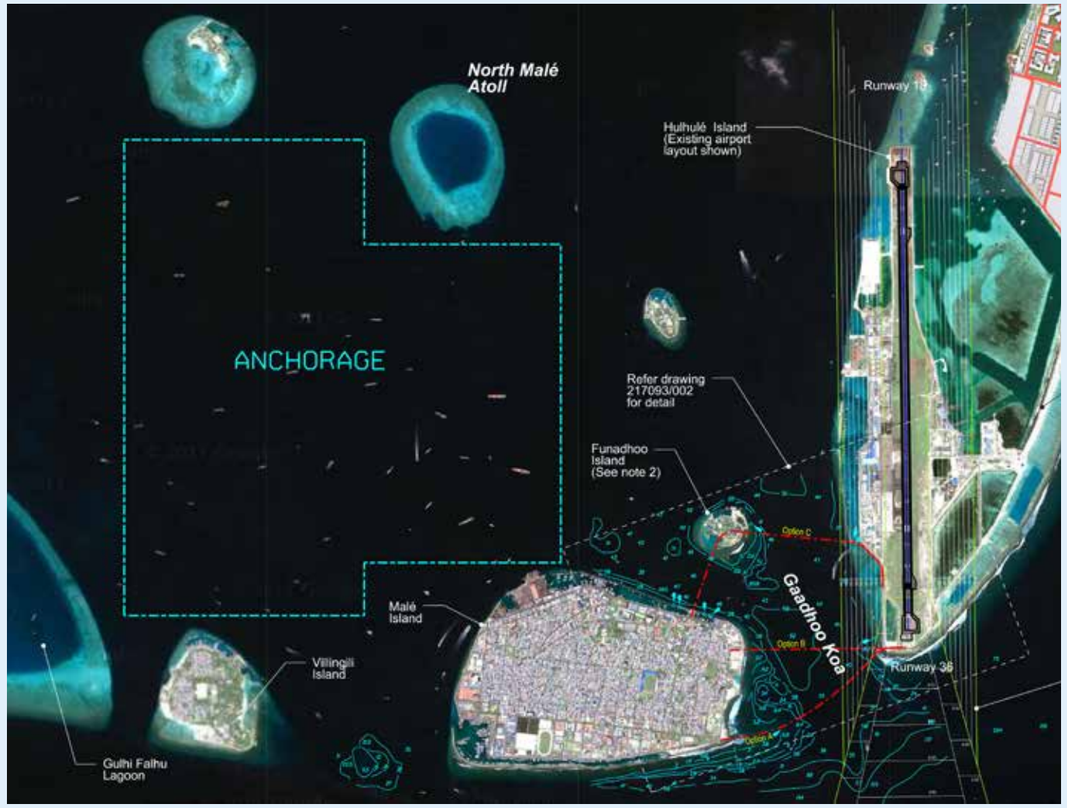




The image shown at the bottom is from a feasibility report conducted in 2011. Three options for the path of the bridge are shown. The report notes that Option A is most feasible. The vertical lines on both sides of the airport runway are the obstruction surface limits. The bridge has to have a height of less than 45 metres near the airport constraining choices of bridge types.

Note the depth contour lines. The China-Maldives Friendship Bridge follows Option A. The maximum depth is about 35 metres. The diagram below is a 3D drawing of the seabed.





Boreholes were drilled to various depths on land and sea in May – June of 2015. The samples show that even at depths of 60 metres below sea level, the ground is invariably coral. The bearing capacity of coral is low hence requiring large piles to support the bridge.

Differing from ordinary rock and soil, the coral reef has the characteristics of low density, large porosity, strong structure, high brittleness and obvious variation of intensity in different directions. These characteristics are directly related to the complexity of probiotic diagenesis of reef limestone, the degree of cementation and the environmental change under the action of post-diagenesis, which reflects the extreme complex geotechnical engineering properties. In the engineering industry, there is the lack of systematic understanding of the engineering geological characteristics of coral reefs and the lack of survey and design specifications and large bridge construction experience under the similar geological conditions.

本项目工程地质为珊瑚礁灰岩，不同于普通岩土，珊瑚礁具有密度低、孔隙大、结构性强、脆性大、强度各向异性显著的特点。这些特征与礁灰岩原生生物成岩的复杂性、胶结程度、后期成岩作用环境的变化直接关联，显示出极为复杂的岩土工程特性，工程界对珊瑚礁的工程地质特性缺少系统的认识，也缺乏类似地质条件的勘察设计规范及大型桥梁建设经验。

THE BUILDING TEAM

1、设计单位全称（也是总建筑总设计者和总工程设计者）：中交公路规划设计院有限公司

1. Design Company (also referred to as: Chief Designer of General Construction and Chief Engineer Designer): CCCC Highway Consultants Co., Ltd.

2、承包商公司全称：中交第二航务工程局有限公司

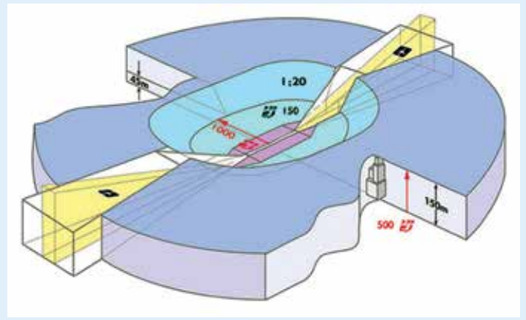
2. EPC Contractor: CCCC Second Harbour Engineering Co., Ltd.

3、咨询及项目管理公司：中交公路规划设计院有限公司

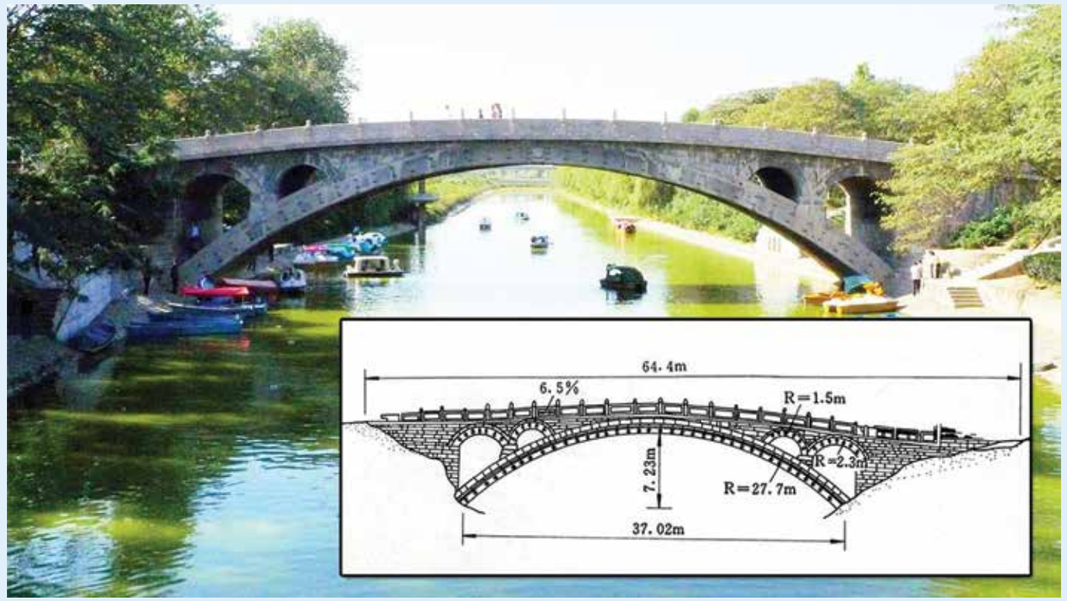
3. Consultant and Project Management Company: CCCC Highway Consultants Co., Ltd.

The Design of the Bridge

Two considerations restrict the type of the bridge that can be built across the channel. One is the geology of the area — coral limestone. The other is the location of the international airport close by. In fact, ICAO rules specify that the bridge height must be under 45 metres near the strait because the area falls within the Obstruction Limitation Surfaces of the runway. Therefore, only two types of bridges are possible. One is a segmental bridge and the other is an arch bridge. The designers chose multiple arches to reduce costs.



由于大桥桥位离马累国际机场跑道很近，在不影响航空运行的条件下，对大桥施工作业高度的要求，最严苛的区域限高小于5米，最宽松区域45米。因此，航空限高制约着桥梁设计方案的选取，也影响着施工方案选择、工效发挥和施工组织。



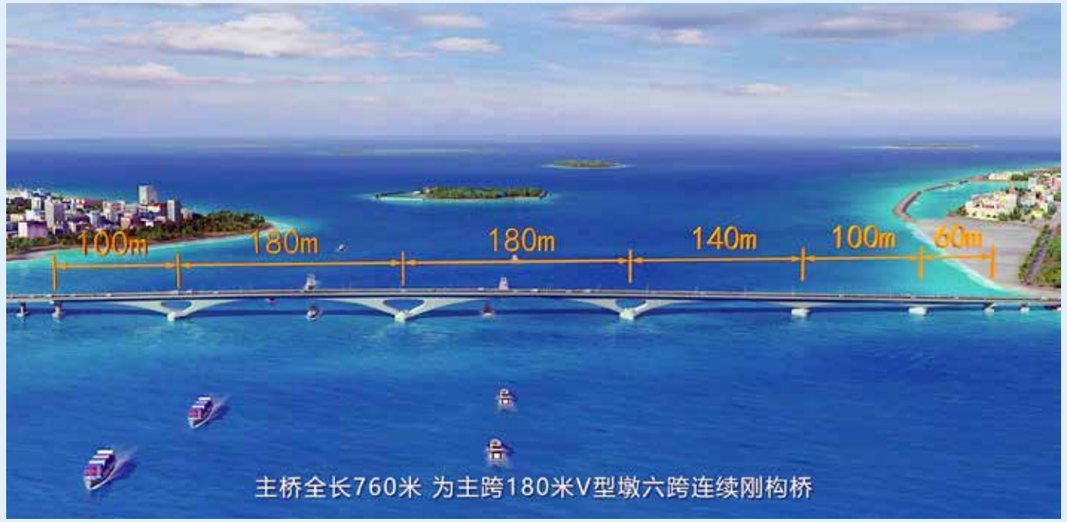
The Chinese are master bridge builders holding several world records. The above modern-looking bridge is actually the world's oldest open-spandrel segmental arch bridge of stone construction built by Li Chun between 595–605. The China-Maldives Friendship bridge has a remarkable similarity with this elegant Anji or Zhaozhou Bridge.

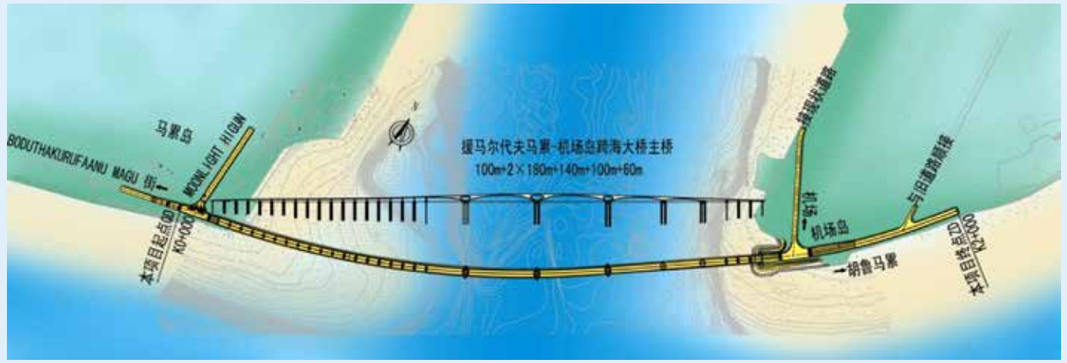
中国人是桥梁建造大师，拥有多项世界纪录。实际上，上面这座现代化桥梁是由李春在公元605年至595年间建造，是世界上最古老的开放式拱形桥。中马友谊大桥与这座优雅的安吉桥（又名赵州桥）有着惊人的相似之处。

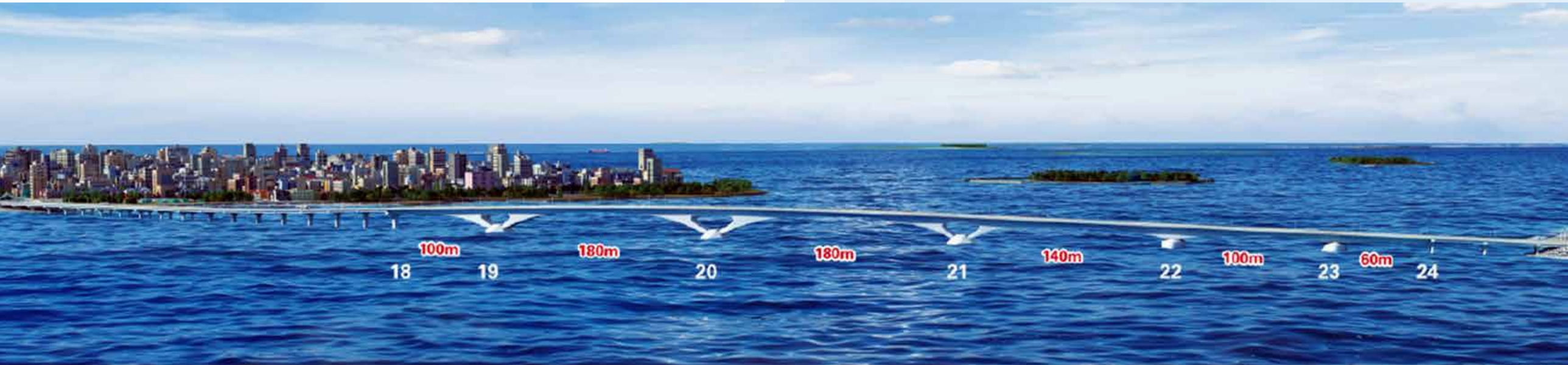
These images show the bridge as conceptualized. The designers chose to span the strait using six arch segments of various sizes. The longest spans are 180 metres long. The approaches are girder bridges. Given the constraints, these are sound decisions.

The bridge is built on 26 piers each of which has four or more piles. The arch sections at sea has larger piles.

这些图片均是概念图。设计师选择用六个不同尺寸的拱形段来横跨海峡。其中最长跨的长度为180米。引桥为梁式桥。鉴于各种限制，以上均为合理决定。







The Trestle Bridge
栈桥

The trestle bridge is a temporary platform bridge built to facilitate the construction of the actual bridge. This bridge was built on the western (Malé) side of the actual one, so the construction of the bridge proper was somewhat hidden from Malé beach area. It was disassembled after opening the completed bridge. The trestle bridge is all steel and was used to carry men and materials for the actual construction.

栈桥是一座临时平台，以便建造实际待建大桥。因为栈桥建立在大桥西侧（马累侧），恰好挡住大桥，所以，在马累沙滩区域看不到大桥的施工过程。在大桥建成并通车后，将拆除该栈桥。栈桥整体是用钢铁建造，用于输送大桥施工所需的人员及材料。

Following the survey of the bridge site and the construction of the workers' quarters, the making of the bridge began. The first visible sign of the bridge being built in the sea was the arrival of barges and barge-mounted cranes from China. The crane barges were the largest ever to be seen in the Maldives. One had a lifting capacity of 1000 tonnes. They were brought on a special ship on 25th February 2016. The barges were unloaded by partially sinking the ship.

Using GPS positioning and survey data, large diameter pipes (casings) for the main platforms were driven into the sea bed. These were held in a structure mounted on the barge while being driven into the seabed by a hammer. On these were built temporary platforms.

The ship-mounted cranes were brought to the Maldives by a special ship in February 2016.

2016年2月，一艘特殊的船将这些浮吊运至马尔代夫。

The photo shown below, taken on 31st March 2017 from the Eastern esplanade, shows two barge cranes active on sinking the pile casings. Apart from landing side preparations, the mooring of barge cranes was the first indication that the dream of ae bridge across Gaadhoo Kolu would be realized. At all times of the day, people gathered on the esplanade to watch the magic of bridge-building taking place.

以下照片拍摄于2017年3月31日马累东部空地，显示两艘浮吊正在放置钢管桩。除陆地上的准备工作之外，浮吊的停泊是实现横跨Gaadhoo Kolhu海峡的大桥这一梦想的第一个标志。人们每天都聚集在海边观看大桥建设的过程。

Taken on 10th April 2016, the above photo shows the start of the construction of the trestle bridge. Construction started from both ends. The middle section was joined only by a suspended walkway. The image on the top left was taken on 27th April 2016. The trestle bridge piers were first built. They served as a platform from which the main pier piles could be driven into the seabed. The bottom photo shows the trestle bridge a month after start.

以上照片拍摄于2016年4月10日，显示开始施工栈桥。这项工作从两端开始，中间部分仅由一条人行悬索桥连接。左上角图片拍摄于2016年4月27日。首先建造栈桥桥墩。栈桥是一座平台，主桥桥桩能够从此打入海底。底部照片显示了栈桥开工一个月后的情况。

In shallower regions, the trestle bridge was built by driving in about 600 mm diameter tubes of about 18 mm thickness by a crane. These formed the legs of the trestle. They were braced to make them sturdy. The crane driving the piles were moved along the trestle bridge as parts were completed. In deeper regions, tubes of about 1200 mm diameter were used as in the photo on the right taken on 23rd December 2018. Note that the deck of the bridge was supported only on two "legs". Where the main bridge piers were located, the platform was on legs of about 2000 mm diameter. There were four such legs for each platform.

在较浅的区域中，通过用起重机驱动约600mm直径的约18mm厚的管来建造栈桥。这些形成了栈桥的腿。他们被支撑起来使它们坚固。部件完成后，驱动桩的起重机沿着栈桥移动。在更深的地区，使用直径约1200毫米的管子，如2018年12月23日右侧照片所示。注意，桥梁的甲板仅支撑在两个“腿”上。在主桥墩所在的位置，平台位于直径约2000毫米的腿上。每个平台有四条这样的腿。

After the trestle legs were driven in, the platform from which the main piers would be constructed was dropped into the legs, each of which was about 2000 mm in diameter. The first platform was dropped on 16th April 2016. The platforms were made in China. These were removed once the bridge was completed.

在推进支架腿之后，将构成主墩的平台放入支腿中，每个支腿的直径约为2米。第一个平台于2016年4月16日撤销。这些平台是在中国制造的。桥梁完工后，这些被移除。