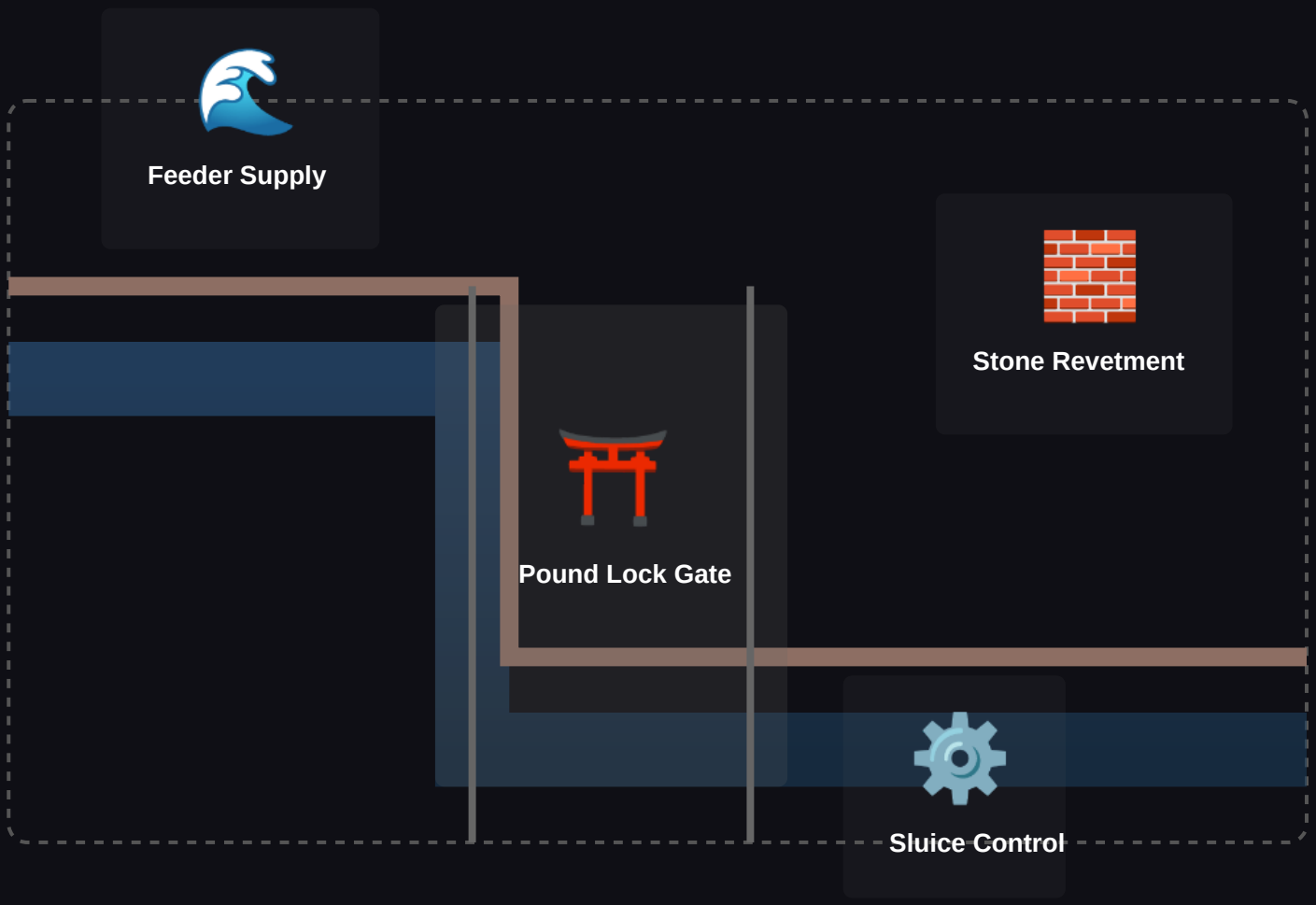

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Hydraulic engineering and lock mechanisms of the medieval Grand Canal

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The Pound Lock Mechanism

Developed in 984 AD by Qiao Weiyue, the pound lock was a revolutionary advancement over the primitive flash lock. It consists of a chamber with gates at both ends, allowing boats to be raised or lowered by controlling the water level within the chamber itself. This eliminated the need to haul boats up dangerous slipways and significantly reduced water waste.

The gates were massive timber structures, often reinforced with iron, that could withstand the immense lateral pressure of the stepped water levels. This mechanism allowed the Grand Canal to navigate the ‘Shandong Summit’—the highest point of the canal—effectively creating a ‘staircase’ of water across the landscape.

Sluice and Flow Control

Sluice gates (Doumen) were vertical sliding barriers used to regulate the volume of water entering or exiting the canal sections. In medieval China, these were often operated via large wooden winches and pulleys.

Beyond just navigation, these gates served a dual purpose in flood control. During periods of heavy siltation or flooding from the Yellow River, the sluice gates could be adjusted to divert sediment-heavy water into secondary basins, preventing the main canal from clogging. This required a sophisticated understanding of fluid dynamics and sediment transport long before the formalization of modern hydraulic physics.

Feeder Supply and Reservoirs

The Grand Canal’s biggest challenge was maintaining water levels on its higher reaches where natural river flow was insufficient. Engineering solutions involved creating ‘Feeder Canals’ that diverted water from distant mountain springs and rivers like the Wen and the Ning.

The most famous example is the Nanwang Hub, a complex water-diversion project that used a T-junction to split incoming water—sending 60% north toward Beijing and 40% south toward the Yangtze. This required precise topographic surveying to ensure the water would flow naturally by gravity over hundreds of miles.

Stone Revetments and Masonry

To prevent the banks of the canal from eroding under the constant movement of water and boats, medieval engineers developed ‘Tiaoshi’ or strip-stone revetments. These were massive blocks of granite or limestone laid in interlocking patterns.

The mortar used was a ‘sticky rice lime mortar’—a composite material of slaked lime and sticky rice soup that created a water-resistant, incredibly strong bond. In high-stress areas, iron ‘swallow-tail’ staples were used to physically lock adjacent stones together, a precursor to modern reinforced concrete techniques.

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