Circular Economy: Challenges In the Reuse of Building Materials - Case Study in a Port Project at a Greek Island

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Abstract. As economies shift from a linear to a circular model — emphasizing prolonged use and reuse of resources — the reuse of building materials becomes imperative, especially in resource-constrained environments like Greek islands. This paper presents a case study involving the attempt to reuse precast concrete blocks and embankment materials from a previously abandoned port project at Amorgos Island. The original construction was halted, leaving substantial materials deposited on a nearby beach, dividing it in two parts, altering the natural coastline. Nearly two decades later, a new port design aim to incorporate most of these materials. While several technical challenges arose, mostly due to the aged concrete blocks, all materials were eventually reused, either in their original form or as fill material. The project not only reduced the environmental footprint by minimizing waste, resources extraction and difficult sea transfer from a far island, but also restored the affected beach area, gaining public acceptance.

Keywords: Circular economy, reuse, building materials, AEKK, coastal engineering, island sustainability

1 Excavation, Construction & Demolition Waste (AEKK)

Excavation, construction, and demolition waste (AEKK) are among the most voluminous waste streams in the European Union, accounting for 25–30% of total waste production [4]. These include concrete, soil, bricks, metals, wood and other recyclable materials, generated from the construction and demolition of buildings and infrastructure. Studies show that transitioning to a circular economy could cut EU CO_2 emissions up to 50% by 2030 [6].

Despite longstanding EU directives (e.g. Directive 2008/98/EC, 94/62/EC, and 1999/31/EC), national implementation varies. Cities like Amsterdam and London lead the way with initiatives like Circular Amsterdam and the London Circular Economy Route Map [5], aiming to keep products, components and materials at their highest use and value at all times, looking forward to an alternative to the current linear economy [1], using it as a tool to save the climate [2],[7].

Also, private companies like the wind turbines manufactures Vestas and Siemens Gamesa, have developed fins from recyclable materials, while the Greek PPC Renewables company develops the Repowering process for the proper management of materials and the complete recycling of the main components of a wind farm.

In general, AEKK management in Greece remains underdeveloped. According to the Hellenic Recycling Agency (EOAN), reuse rates remain low despite increasing AEKK quantities due to widespread home renovations. Table 1 illustrates national performance from 2016 to 2022:

Table 1. Management of Excavation, Construction and Demolition Waste (AEKK) in Greece

	Ingoing quantities			**Outgoing quantities of materials to be recovered**		
YEAR	**Excavation Waste** (tn)	**Construction & Demolition Waste** (tn)	**TOTAL** (tn)	**Recycling** (tn)	**Backfill** (tn)	**Total Recovery** (tn)
2016	335.655	193.429	529.084	128.815	135.108	263.923
2017	556.065	434.390	990.455	196.925	540.884	737.809
2018	1.693.887	1.160.304	2.854.191	599.755	1.564.712	2.164.467
2019	1.803.832	1.623.035	3.426.867	1.516.670	835.432	2.352.102
2020	1.891.340	3.403.675	5.295.015	1.701.961	1.190.519	2.892.480
2021	2.864.847	3.784.272	6.649.119	2.462.296	2.403.565	4.865.861
2022	4.299.994	5.565.173	9.865.167	3.143.773	3.061.958	6.205.731

2 Greek Legal Framework

The legal framework addressing AEKK management in Greece includes:

- The Joint Ministerial Decision No. 36259/1757/E103/2010 Official Gazette 1312/B/24-8-2010, describes "Measures, conditions and programming for the alternative management of waste from excavations, constructions and demolitions (AEKK)". The accounting costs of a construction project includes also the A.E.K.K. reception fee. (asphalt, stones, soils, gravel, lightly reinforced concrete, etc.) where decision 4834/25-01-2013 is clarifying the requirements
- Common Ministerial decision 50910/2727/2003: Measures and Conditions for Solid Waste Management. National and Regional Management Planning
- Directive Nr. Oik.129043/4345/8-7-2011: Implementation of legislation for the management of non-hazardous solid waste
- Law 4030/2011 FEK 249/A/25-11-2011, article 40 refers to “Issues related to wastes from excavation, construction and demolition (AEKK)”
- Law 4042/2012 (ΦΕΚ 24/A/13-02-2012), article 27 refers to "Reuse and recycling”
- Common Ministerial decision 43942/4026/2016 describes the Electronic Waste Registry’s operation

3 Limited Resources on Small Islands

Greek islands face unique environmental and logistical challenges. Scarcity of natural resources necessitates material imports, often from distant quarries such as those on Leros Island located in the Dodecanese. This adds environmental and economic burden. Consequently, any effort to reuse existing materials locally is particularly valuable [8]. However, the environmental impact of transporting and disposing of unused materials is often underestimated, since it is business as usual.

4 Initial Design of a Fishing Shelter

In 2002, the Greek Tourism Organization (EOT) designed a fishing shelter at Xylokeratidi area, Amorgos Island. Construction began, with on-site production of precast blocks and importation of embankment materials. However, the project was cancelled after legal objections regarding poor design and environmental concerns.

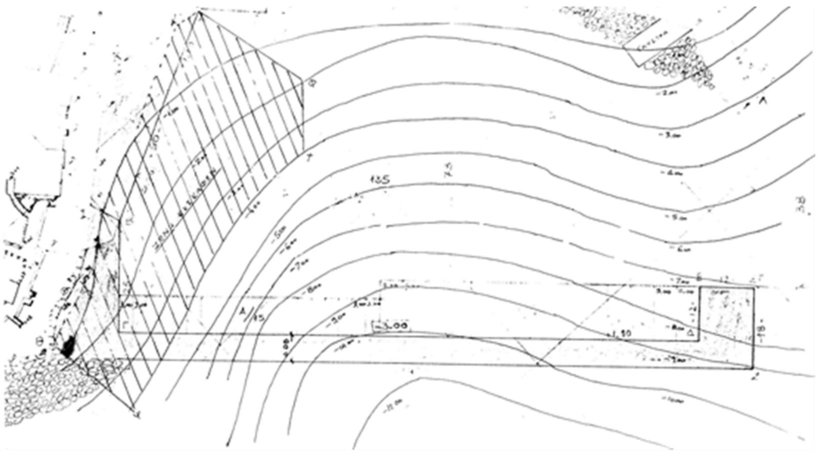

Fig. 1. Initial planning of the fishing shelter. The breakwater would be formed with vertical docks, crossing the bathymetric contours up to -10.50 m deep, needing huge amount of construction materials

Photo 1. The picturesque spot at Xylokeratidi bay where the numerous fishing boats were not able to berth

After project cancellation, materials were just abandoned on Katapola beach, forming a new artificial pier (~1,780 m²) consequently altering the coastal morphology, causing public outcry demanding their removal.

Quantities included:

- ~3,000 m³ of embankment material
- 12 solid concrete blocks (2.0 × 3.0 × 1.5 m → 108 m³)
- 5 large cellular blocks (4.0 × 7.0 × 1.3 m → 182 m³)

Photo 2. The new pier at Katapola beach on 2015, consisted of embankment material and three types of 17 concrete blocks, abandoned on site 10 years ago

A whole new pier was formed covering the central part of Katapola beach, transforming it into a construction site for a period of 16 whole years, degrading the beach and the environment.

Photo 3. Embankment materials and artificial blocks deposited from the previous contract. Residents' reactions aiming to their removal were continuous, as can be seen on the protest banner

Photo 4. The large-sized cellular artificial blocks were difficult to manage, causing great dissatisfaction

5 Revised Port Design and Material Reuse

In a subsequent design, the port plan was modified to follow seabed contours, reducing both material requirements and wave reflections. During the new study (Fig. 2.), the port basin has been protected by a composite breakwater designed to mostly follow the relief of the sea bottom, aiming to save construction materials, as well.

Natural rocks were used to protect the external breakwater from high waves propagating through the central Aegean Sea, protecting also the buildings on the coast.

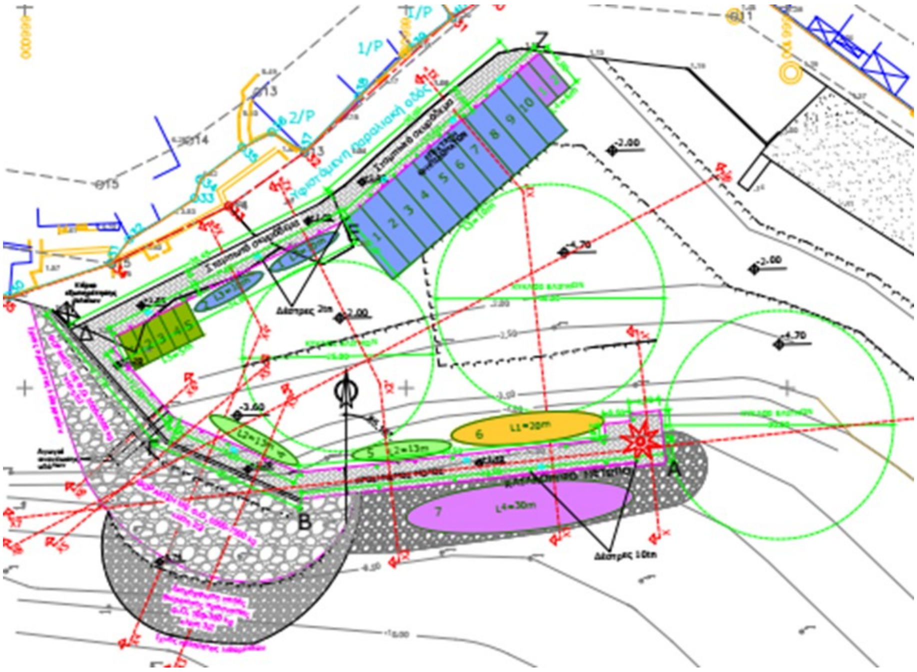

Fig. 2. New fishing shelter's design, following sea bottom's contours, minimizing construction material. The docks are protected by natural stones, reducing wave reflections

Further on, the new design had to be adapted to incorporate all embankment material and artificial blocks deposited on the beach from the previous contract.

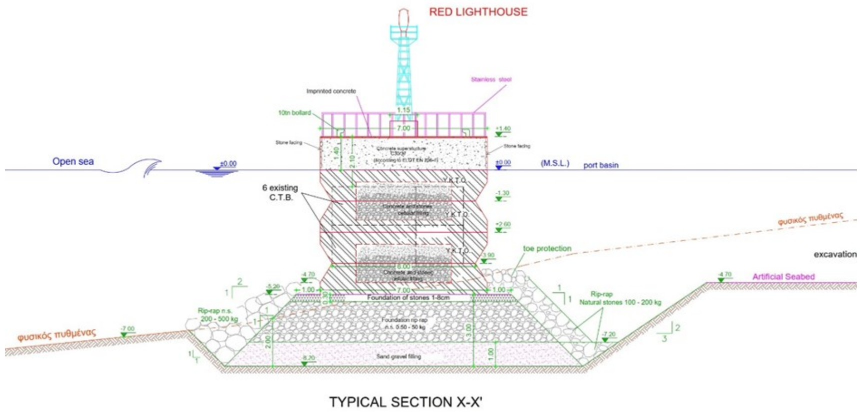

Fig. 3. The biggest of the existed cellular blocks were intended to form the shelter's breakwater head, but they finally broke

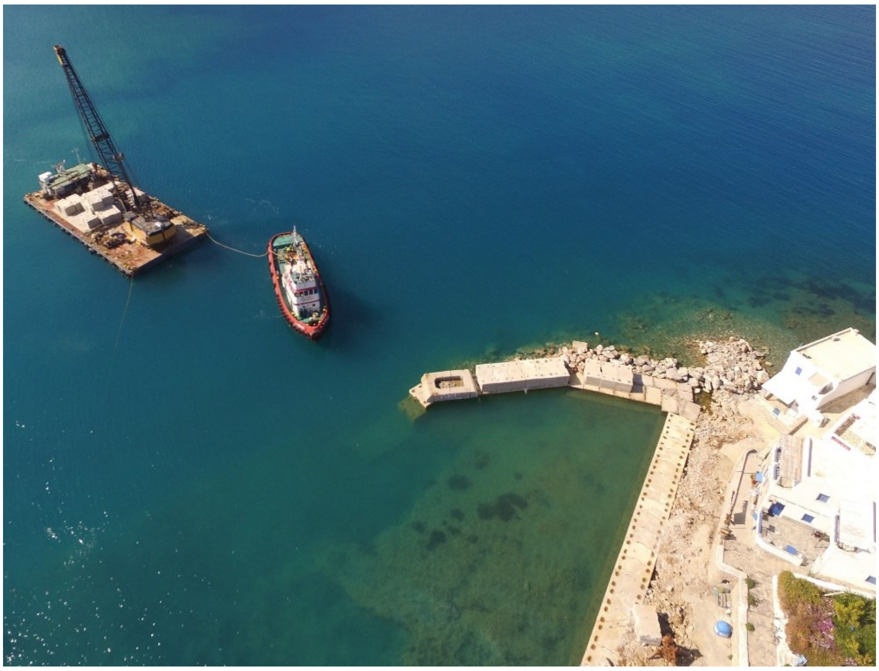

Photo 5. Existed cellular artificial "OXI" block on the way to the shelter's breakwater head

Photo 6. Heavy machinery was used to remove embankment material from the coast

The new contractor had to use heavy machinery to reclaim and reuse the materials, as seen in the previous photos. During the transportation of the blocks from the deposit area to the construction site, many blocks were damaged (as seen in Photo 8) likely due to material degradation during the 16 years deposition period, forcing their use as embankment fill instead of structural elements.

Photo 7. The “OXI” named block ready to be transferred into the shelter’s breakwater

Photo 8. Several existed artificial blocks were damaged during transportation and used as embankment material

Nevertheless, the reuse of the material deposited on the Katapola coast was very beneficial to the construction of the new fishing port and welcome to the residents, since the coast was reshaped to its original form in two years period.

This case study illustrates a broader challenge in circular economy: materials intended for direct reuse, such us concrete blocks, slabs, metallic frames etc. often require processing, testing or partial demolition before reincorporation.

6 Project Outcomes and Environmental Restoration

The reuse strategy achieved multiple goals:

- **Environmental:** Reduced quarrying and construction waste
- **Economic:** Lower transport and material costs
- **Social:** Restored public access to Katapola beach, resolving long-standing grievances

Within two years, the beach was fully reshaped becoming a swimming and wellness spot for the residents and the tourists (as it was before).

Photos 9. & 10. Satellite and drone taken photos of Katapola bay, before (9) and after (10) the construction of the fishing shelter (formed on the left side of Katapola bay). The artificial pier's materials have been incorporated into shelter's breakwater. The beach has been already returned to its initial condition

Photo 11. Comparison between Katapola beach (2015) covered by contactor's materials and

Photo 12.….the beach is freed and naturally reshaped (2022) after the construction of the shelter

7 Conclusion

Circular economy principles are especially relevant for insular and remote regions. Reusing existing materials - even when not in their original form - can significantly reduce environmental impact, construction costs, and community resistance. This case study highlights the importance of flexible design, stakeholder engagement, and adaptive reuse strategies in sustainable coastal infrastructure development.

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