

Integration of Land and Sea in a Port Area: A Case Study of the Port of Koper

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Abstract. The spatial plan for a port based on land reclamation, existing land, or a combination of both should be designed in line with both reliable data for the existing situation and precise goals based on a well-founded vision by the port authority. In ports, human activities are concentrated in the limited space of the coastal belt, where they threaten the vulnerable equilibrium of the environment. Integrated multifunctional planning of ports is necessary for the sustainability of such plans. In this process, the relation between the environment and the economy is often neglected because the ecosystem—the totality of living organisms—which is fully dependent on biological, chemical, and physical factors, prevails. This method, also called building with nature, is the basis for integrated coastal zone development and management. It emphasizes the flexible integration of land and sea, which respects and uses forces and materials present in nature, and which is an essential interaction between man and environment. Strict ecological planning conditions and the public interest obliged the Port of Koper to modify its urban planning strategies and redefine its relationship with all bordering areas. The extension of two piers and construction of a third one was the result of functional factors, infrastructure connections, technical possibilities, and environmental requirements. Solutions that were relevant for distributing cargo on the docks had to adjust to the width of the basins for manoeuvring ships. Various types of construction restrict water flow under piers, thereby accelerating biomass degradation. Environmental aspects created conditions and requirements for pier construction.

1. Introduction

The Port of Koper is the youngest modern North Adriatic port, which was constructed after the Second World War to provide sea access for Slovenia as a consequence of post-war territorial changes in the North Adriatic [1]. It first developed on the north side of the former island of Koper, previously used for shipping by small coastal ships. The first pier for oceangoing vessels in the Gulf of Koper was completed in December 1957. From then on, the Port of Koper developed rapidly because of its advantageous location and its potential for expansion [2]. Strict ecological planning conditions and the public interest obliged the Port of Koper to modify its urban planning strategies and redefine its relationship with all neighbouring areas. In 2007, a solution for further spatial expansion of the Port of Koper was proposed; this has been expanded in the *Professional Guidelines for the National Master Plan of the Port of Koper*. In 2011, the Slovenian government adopted the *National Spatial Plan for the Port of Koper* based on professional guidelines [3], and today the port is slowly implementing these planned steps (e.g., dredging the first basin).



The transformation of coastal or river waterfronts is among the most interesting phenomena in urban redevelopment because the coastal belt is properly considered an exceptional location. When considering waterfronts, the coastal area in the northeast part of the old town of Koper is a very interesting laboratory that has been intensely transformed in a short timeframe [4]. Research in the area usually focuses on publicly accessible coastal areas, and not on parts of areas that are closed to the public, such as the port area, although these are very important for maintaining quality living space and ecological values. The objectives of this research are to present the planning process for the piers and operative coasts for the *Professional Guidelines for the National Master Plan of the Port of Koper*, as well as factors that have influenced the design of the pier's spatial and construction elements. The premise is that integrated planning of coastal areas is still insufficient and has a number of shortcomings.



Figure 1. Three piers as planned in the *Professional Guidelines for the National Master Plan of the Port of Koper*

2. Methodology

The extension of two piers and construction of a third one in the *Professional Guidelines for the National Master Plan of the Port of Koper* (figure 1) was the result of functional factors, infrastructure connections, technical options, and environmental requirements [5]. The analytical assessment highlights key elements of spatial transformations of the piers in four decisive phases. The key elements are:

- Function: the use of and activities designated for the pier platforms and the buildings on the platforms;
- Shape: the physical form of the piers, and their outlines and edges;
- Construction: the features of the pier structure;
- Traffic network: roads, railway tracks, and other thoroughfares;
- Environmental conditions: the configuration and the change in the natural environment.

Four phases were identified in planning the three piers at the Port of Koper:

- The first phase, in which competition requirements were set;
- The second phase, in which the competition proposal was defined;
- The third phase, in which *Professional Guidelines for the National Spatial Plan for the Port of Koper* were completed;
- The fourth phase, in which environmental assessment of the *Professional Guidelines for the National Spatial Plan for the Port of Koper* was given.

All four phases recognized as part of planning the piers and the operative coasts are studied through defined key elements, which allow equalization of factors influencing the design of the piers' spatial and construction elements.

3. Results and discussion

The competition requirements in the first phase state that it is necessary to design highly productive terminals in one location because some terminals in the existing configuration (figure 2) are divided into several areas. Transshipment of containers and cars should be arranged on the first pier, and transshipment of cars on the second pier. The core area of the third pier is intended for transshipment of containers and cars, and a ro-ro terminal.

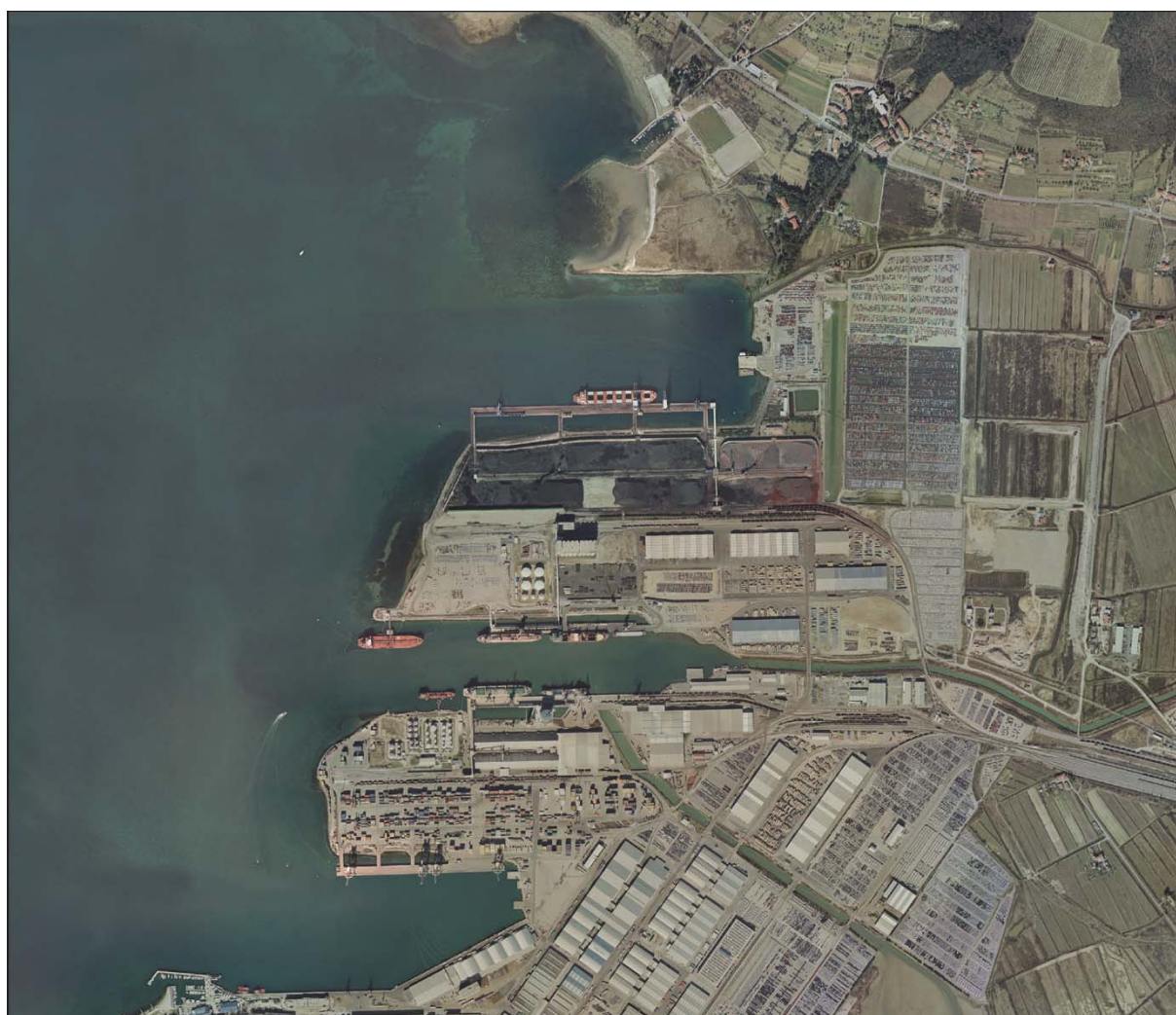


Figure 2. The Port of Koper area in 2007

Spatial development of the operational coast should be directed into extension of the piers. The first pier needs to be extended to the west by a length of 350 m and a width of 475 m. The second pier should also be extended to the west by a length of 400 m and a width of 500 m of operative coast at the head of the pier. The third pier needs to be built with a length of 700 to 1,000 m and a width of 250 to 350 m of operative coast.

The project task does not mention any requirements about the construction, but it points to harmonizing the road and rail network of the port, both within the Port of Koper and in its interaction with European corridors. The coordination of types and forms of cargo throughput, spatial solutions, and environmental issues, further development of the port, and arrangements of areas neighbouring the port to reduce negative impacts on the environment is the key issue of the project requirements.

The competition proposal was defined in the second phase. It follows the instructions on the extension of the piers towards the west, and through this extension the port will obtain significantly more space for terminals. A container terminal and fruit terminal are located on the first pier, and the second pier has a terminal for dry bulk cargoes, EE terminal, terminal for liquid cargo, and terminal for cereals. The third pier is intended only for a container terminal.



Figure 3. Shape and edges of all three piers in the second phase (prepared by Tomaž Berčič)

The main design features of the piers are twofold (figure 3). The basins between the piers are narrow, allowing a maximum width of piers and consequently a maximum storage and off-loading area; the ends of the piers are highly segmented in order to obtain a longer operational port coast. Broad, high green mounds on the north side of the third pier separate the housing in Ankaran from the container terminal on the third pier.

The competition solution does not define the construction systems, but it does identify the transport networks. A primary road and rail tracks are planned for each pier, and the second pier has a clearly defined improved secondary road network.

The purpose of the strategy for the port is not only to follow environmental measures, but also to take a leading role in ecological strategies and policies in general in ports. For this purpose, a modern educational center for various types of green energy production in the port has been established. The green waves of the roofs of the new port prevent the effects of industrialization in nearby areas posed by development of the port and at the same time lower the temperature in the immediate vicinity.

In the third phase, the *Professional Guidelines for the National Spatial Plan for the Port of Koper* were completed. The quantity of areas of activities changed in this phase (table 1). Corrections were already made before starting the third phase, but there were only small changes in areas in the container terminal and fruit terminal. However, the third phase substantially changed the area of the EE terminal, liquid cargo terminal, and terminal for cereals, which became larger. On the other hand, the dry bulk cargo terminal, fruit terminal, and container terminal became smaller. On the first pier and third pier, the activities remained the same, but on the second pier an area for general cargo was added. All changes in the use of the pier area and the size of the areas were demanded by individual centers at the Port of Koper, which only provided detailed instructions for planning in the third phase.

Table 1. Comparison of the area of the terminals on the three piers in the second and third phases.

	Second phase (m ²)	Second-phase corrections (m ²)	Third phase (m ²)
Container terminal	805.000	795.000	780.000
Fruit terminal	75.000	108.000	83.000
Dry bulk cargo terminal	168.000	168.000	125.000
EE terminal	190.000	190.000	365.000
Liquid cargo terminal	133.000	133.000	211.000
Terminal for cereals	132.000	132.000	207.000

The shapes and edges of all three piers also changed due to additional verifications. Solutions that were relevant for distributing cargo on the docks had to adjust to the width of the basins for maneuvering ships (figure 4).

The total length of operative coast on the south side of the first pier is 700 m, and on the north side 800 m. A small part of the pier construction will be built on improved seafloor. Other coastal and inner platform construction will be built on vertical steel piles with a pile foundation 45 m deep, which will ensure sufficient storage capacity for handling containers.

The length of the second pier is 777 m, and the construction on vertical steel piles will need to be built on pile foundations 30 to 37 m deep. The depth of the seafloor in the area is between 1 m at the existing edge of the pier and 10 m at the estimated edge of the operational coast. All areas 3 m deep will be regulated by depositing material on the seafloor. In areas with a depth of 3 to 10 m, reinforced concrete construction on vertical steel piles will be built [6].

The area of the third pier is only partly filled in, and the entire length of the pier is about 1,050 m. Here the construction of the pier depends on the depth of the soil foundation. In the area where the flysch foundation is a maximum of 25 m deep, the coast will be built up with hopper-reinforced concrete construction. In the area where the flysch foundation is deeper, the construction of vertical steel piles is proposed.

Adjustments were made to the transport systems, but the general idea of the traffic networks remained the same. The guidelines were adopted to ensure the sustainability of the structure mainly by using quality materials.

The environmental assessment of the *Professional Guidelines for the National Spatial Plan for the Port of Koper* was given in the fourth phase. Various factors were considered, including climatic factors, air quality, seawater, inland waters, groundwater, flora, fauna, habitat types, protected natural areas (Natura 2000 protected areas), cultural heritage, landscape features, soil, waste, and light pollution [7].



Figure 4. Shape and edges of all three piers in the third phase (prepared by Tomaž Berčič)

Impact assessment and mitigation measures were part of the report. This study only focuses on construction issues for the three piers. Hopper-reinforced concrete construction restricts the flow of the water mass, which can locally increase biomass (increased concentration of algae and debris, slimy aggregation, and jellyfish), which leads to its accelerated decomposition (i.e., rot) leading to a lack of oxygen in the bottom layer. From the environmental point of view, the only acceptable way of building the piers is to use vertical piles. The typical distance between piles is about 4.25 m or 6 m (figure 5), depending on the type of segments of piers or their load. The report suggests that it would be even better if the distance between the piles were increased to 8 or 12 m, whereby the piles can have a larger diameter and a thicker steel mass for large bearing capacity. In this way, the pier platform would be based on vertical piles above sea level and would not extend into the sea area below the surface.

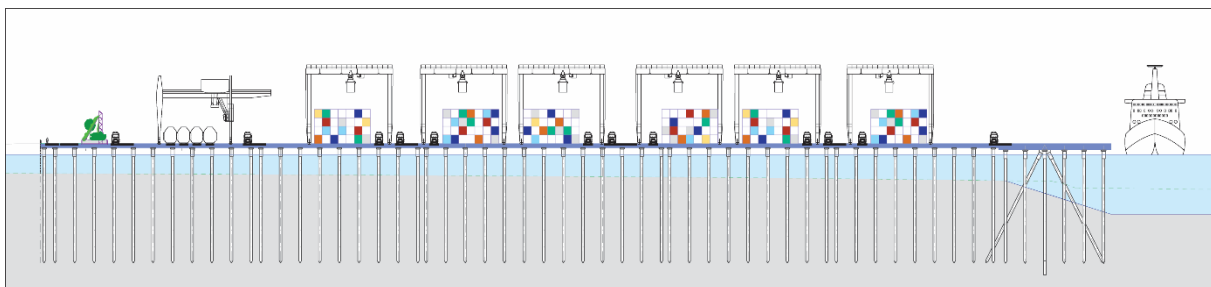


Figure 5. Section of the third pier showing the construction of vertical steel piles

The spatial plan for a port based on land reclamation, existing land, or a combination of both should be designed in line with both reliable data for the existing situation and precise goals based on a well-founded vision by the port authority. Both data were partly missing when the first phase of the project started: for example, the width of the basins for manoeuvring ships was defined rather late in preparing the plan. Integrated multifunctional planning of ports is necessary for the sustainability of such plans. In this case, the project task supported solutions that were described as unacceptable in later phases by the environmental assessment.

In addition, the interaction between sectors and cross-discipline cooperation was not ideal. Problems arose not only because of restrictive protection regimes, but also due to the multitude of interests and poorly determined coastal zone management system [9]. Not competition, but collaboration brings success to complex issues such as integrating land and sea in the port area. In this process, the relation between the environment and the economy is often neglected because the ecosystem—the totality of living organisms, which is fully dependent on biological, chemical, and physical factors—prevails. The final goal in this situation will be a stronger economy and a better environment. To achieve this objective, there must be a conscious effort to provide complete and reliable information from the start of the project, otherwise enormous work can be carried out in vain. The premise was confirmed that, when dealing with such a vulnerable space as the area between land and the sea, integrated planning has not yet been harmonized and different viewpoints are not being taken into consideration equally.

4. Conclusion

In ports, human activities are concentrated in the limited space of the coastal belt, where they threaten the vulnerable equilibrium of the environment. There are limited spatial solutions in such a valuable environment. One of them is a method called building with nature, which is the basis for integrated coastal zone development and management. It emphasizes the flexible integration of land and sea, which respects and uses forces and materials present in nature, and which is an essential interaction between man and the environment.

References

- [1] L. Ažman Momirski, “The Port of Koper: the youngest modern North Adriatic port = El puerto de Koper: el puerto moderno más reciente del Adriático norte”, *Portus*, y. 4, no. 7, pp. 70-75, 2004.
- [2] L. Ažman Momirski, “Port of Koper: new models of port-city relationship = Puerto de Koper: nuevos modelos para la relación puerto-ciudad”, *Portus*, y. 10, no. 20, pp. 12-17, 2010.
- [3] L. Ažman Momirski, “The ports of Koper, Trieste, and Rijeka after the Second World War: a comparative study of shifts in physical structure, economic development, and political decisions”, *Cities in Europe, cities in the world*, Lisbon, pp. 1-13, 2014.
- [4] L. Ažman Momirski, “Urban waterfronts in Koper: a comparison of spatial issues in the initial and current plans for Koper’s port”, *Annales, Series historia et sociologia*, vol. 25/1, pp. 19-32, 2015.
- [5] L. Ažman Momirski and M. Venturi, “The National Spatial Plan for a comprehensive spatial arrangement of the Port of Koper: container terminal: professional guidelines: urbanism, architecture, landscape design”, *Lasscan, PNZ svetovanje projektiranje*, 2010.
- [6] L. Battelino, “The National Spatial Plan for a comprehensive spatial arrangement of the Port of Koper: port infrastructure: professional guidelines”, *Lasscan, PNZ svetovanje projektiranje*, 2010.
- [7] M. Žerdin, “Environmental impact assessment for the National Spatial Plan for a comprehensive spatial arrangement of the Port of Koper”, *AQUARIUS d.o.o. Ljubljana*, 2009.
- [8] G. Čok, “Designing baselines for developing an integrated coastal zone management system in the Adriatic: experience in Slovenia”, *Architecture, city and environment*, y. 11, no. 33, pp. 15-32, 2017.
- [9] R. E. Waterman, “Sustainable coastal zone development in harmony with the natural environment”, Delft, 2000.