Dynamic Stock Analysis of Residential Building Materials in the Pays de la Loire Region, France, Using Artificial Neural Network (ANN) Models

Youcef CHACALI[1], Fateh ZENATI[3], Mustapha NOURI[1,2], Mahfoud TAHLAITI[1,2]

1: Icam, Site de Nantes, 35 Av. du Champ de Manoeuvres, 44470 Carquefou, France

2 : Ecole Centrale de Nantes, Nantes Universite, CNRS, GeM, UMR 6183, 44000 Nantes, France

3 : Université des Sciences et de la Technologie Houari Boumediène (USTHB), algiers, Algeria

Abstract :

The concept of Urban Mining proposes a transformative vision by considering the built environment as a regional resource mine. It views urban areas not only as places of consumption, but also as strategic reservoirs of raw materials that can be recovered at the end of a building's life. However, the lack of short- and medium-term visibility regarding the type and quantity of recoverable materials remains a major limitation. Therefore, a combined analysis of material stocks and inflows and outflows represents a key challenge for understanding and managing the metabolism of socio-economic systems. In this context, a bottom-up, building-by-building methodology based on an artificial intelligence model was developed and applied to the Pays de la Loire region in France. This study aims to identify the main material stocks and flows resulting from the deconstruction of residential buildings in order to provide a detailed understanding of the resources available in the territory. The study led to the development of five artificial neural network (ANN) models to predict the envelope materials of residential buildings including wall type, wall thickness, floor type, and roof type. The French National Building Database (BDNB) was used as the main data source. The results show good accuracy, with high correlation coefficients ($R > 0.90$ for some models) and mean absolute percentage errors (MAPE) below 20%. These models were then used to fill in missing data for 488,953 residential buildings in the regional database. Based on this completed dataset, the total stock of materials in building envelopes was estimated at 92.36 million tonnes (Mt). Concrete accounts for the largest share (74%), followed by stone and mixed aggregates (14%), brick (7%), wood (2%), and tiles (1%). Finally, construction and demolition waste was estimated for the 2024–2030 period using deconstruction scenarios. In 2025, waste generation is estimated at 254 kt, of which 41% originates from Nantes Métropole. Single-family houses account for 79% of the waste, and 65% comes from buildings constructed before 1945. Concrete represents more than 75% of the generated waste. These results make it possible to anticipate waste flows and to adapt resource management and recycling strategies accordingly.

Keywords : Material stock analysis, Circular economy, Waste flow prediction, Bottom-up methodology