



Quantifying climate risk: Foundation damage from drought in mortgage portfolios – Pile rot

Achmea Mortgages

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- 400,000 Dutch homes are at risk of foundation damage from pile rot or differential settlement. This paper focuses on pile rot caused by falling groundwater and drought.
- Portfolio-level financial impact remains limited at 0.4 basis points over the mortgage lifetime. The National Mortgage Guarantee (NHG) and loan-to-value headroom provide strong mitigation.
- Achmea Mortgages has expanded its green loan to include climate-adaptive measures, helping homeowners protect properties and reducing risk.

Introduction

This study assesses the financial implications of foundation damage within Dutch mortgage portfolios, focusing on wood decay in timber pile foundations.

Institutional investors are increasingly integrating climate change and its associated risks into their investment decisions. This trend is also evident among investors in Dutch residential mortgages. Although Dutch mortgages have historically shown strong stability and low credit risk, climate-related factors introduce a new dimension that requires careful analysis.

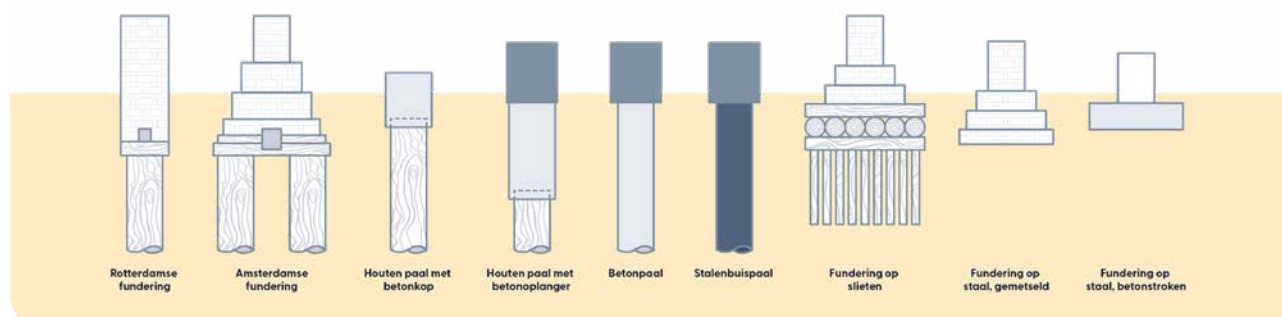
Achmea Mortgages previously assessed climate exposures qualitatively across flood, drought, rainfall, and heat risks. Quantitative flood risk analysis confirmed that dikes provide robust mitigation. Drought-related foundation damage, however, remains uninsured and can impose substantial homeowner costs.

According to a report by the Council for the Environment and Infrastructure (Rli) about 400,000 homes are at risk of foundation damage with news media crowning the situation a “foundation crisis”, showing the relevancy of the subject. Research by Brainbay and ABN AMRO indicates that homes with foundation damage have a 12% lower resale value, while repaired foundations can increase resale value by 2%.

Achmea Mortgages has modeled the potential costs associated with foundation damage within its mortgage portfolio. This paper covers the potential costs due to pile rot damage and a following paper will cover potential costs due to differential settlement damage. Two principal climate-related risks affecting Dutch residential mortgages have been systematically quantified using Monte Carlo simulation and standardized credit risk frameworks. Projected losses incorporate risk-mitigating variables including loan-to-value ratios and state-backed guarantees. The results show that while individual homeowners may face substantial hardship, the aggregate financial risk for investors remains limited due to strong mitigation measures and portfolio diversification.

Drivers behind pile rot damage

FIGURE 1: TYPES OF FOUNDATIONS USED IN THE NETHERLANDS (SOURCE: FUNDERMAPS)



- Shallow foundations: *Fundering op staal, gemetseld*; *Fundering op staal, betonstroken*
- Timber pile foundations: *Rotterdamse fundering*, *Amsterdamse fundering*, *Houten paal met betonkop*

Foundation damage in Dutch residential properties is primarily caused by environmental processes affecting two main foundation types: shallow foundations on clay or peat soils and timber pile foundations. This paper focuses on timber pile foundations. This foundation type relies on constant submersion in groundwater; fluctuations expose the timber to oxygen, increasing the risk of fungal decay and rot. Wooden foundations in sandy soils deteriorate faster than those in clay or peat.

Timber pile foundations are also affected by drought, as they rely on constant groundwater submersion to prevent decay. Lower groundwater exposes timber to fungal attack and rot, especially in alternating wet and dry conditions. Soil chemistry changes, pollution, and urban development can accelerate deterioration. Once damage reaches a critical threshold, the home's structural integrity can quickly decline, making foundation repairs necessary (source: Verbond van Verzekeraars). Understanding these deterioration mechanisms is necessary for estimating repair costs, which vary dramatically based on damage severity.

The costs of pile rot damage

Foundation damage can result in substantial costs for homeowners. Restoration expenses for severely affected homes ranged from €54,000 to €100,000 for an average-sized property in 2019 (source: KCAF). Repairs to timber pile foundations can permanently restore

structural integrity. This contrasts with damage from differential settlement, which may recur as the ground continues to subside (source: Deltares). Repair costs rise sharply with severity, but minor damage can often be addressed for less than €10,000 (source: KCAF). Beyond direct costs, foundation damage also affects market value. Homes with reported foundation damage sell for an average of 12% less, while homes with repaired foundations can achieve a 2% premium compared to similar properties (source: Brainbay, ABN AMRO, ESB).

The table below summarizes the damage classes, required repair work, and associated costs for an average-sized home (200 m³), based on KCAF estimates indexed to 2020 construction costs (source: CBS). The table below is applicable to both pile rot and differential settlement.

With damage costs quantified, it is now possible to model the probability and timing of pile rot across the mortgage portfolio.

TABLE 1: FOUNDATION REPAIR DAMAGE COST CLASSES (SOURCE: KCAF)

Damage class	Required repair work	Repair cost (mean μ , stdev σ)	
D1	Interior painting	μ : €1,610	σ : €966
D2	+ Filling/repairing cracks (exterior), scaffold rental	μ : €3,542	σ : €1,673
D3	+ Plasterwork repair	μ : €7,728	σ : €5,152
D4	+ Repair of window frames and floors	μ : €45,080	σ : €32,200
D5	+ Foundation repair	μ : €96,600	σ : €57,960

Modelling pile rot risk

Damage occurs when timber piles are exposed to oxygen long enough for bacterial or fungal growth, reaching a “point of no return” after which deterioration is inevitable. This makes the timing of damage difficult to predict. The Climate Effect Atlas (*Klimaat-effectatlas*) of Deltares and Climate Adaptation Services provides neighbourhood-level risk maps for expected pile rot in 2050, based on the prevalence of timber pile foundations and average vulnerability. Vulnerability is quantified by the expected damage class at the end of the prediction period, determined by cumulative oxygen exposure, estimated groundwater levels, and soil type. Timber pile foundations in sandy soils deteriorate faster than those in clay or peat. The pile rot risk is determined by two factors: the prevalence of timber pile foundations and the average vulnerability of homes in each neighborhood.

To estimate pile rot costs over the lifetime of a mortgage loan, the foundation type is first inferred using neighbourhood-level prevalence data. The timing of damage occurrence is modeled using an exponential distribution. Repair costs are simulated using a lognormal distribution, which ensures all values are positive and reflects the variability typically seen in real-world expenses.

Monte Carlo simulation

To address uncertainty in foundation risk, the model uses a Monte Carlo simulation with 1,000 iterations per loan. Each iteration generates a possible year and amount of damage. While individual loan outcomes are highly variable, aggregating results across many simulations

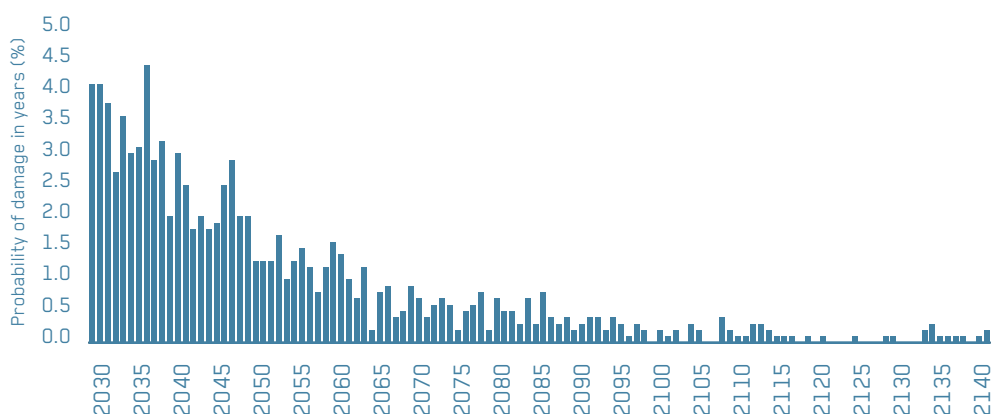


yields statistically robust portfolio-level estimates. Figure 2 shows the results of the damage timing simulations for an example mortgage.

Present value calculations

All future foundation damage costs are discounted to the present value to accurately reflect their financial impact on mortgage portfolios. This approach accounts for both the time value of money and inflation in construction costs. The present value is calculated using swap rates, with discount rates varying based on the expected timing of damage. Inflation is adjusted using a fixed rate of 2.9%, reflecting the increase in construction costs in the Netherlands in 2024 (source: CBS).

FIGURE 2: PROBABILITY OF PILE ROT DAMAGE PER YEAR FOR AN EXAMPLE MORTGAGE



Credit risk modelling

Foundation damage estimates are incorporated into credit risk calculations using the Merton structural model, which treats mortgage loan default as occurring when property value falls below total debt obligations. Repair costs from pile rot or differential settlement are added to debt obligations; if these exceed property value, exposure at default (EAD) arises. The model calculates Probability of Default (PD), Loss Given Default (LGD), and Expected Loss (EL). Mitigating factors for investors include the National Mortgage Guarantee, which limits losses to 10% in case of default, and substantial loan-to-value headroom due to rising home prices. Additional funding from the Sustainable Foundation Repair Fund (*Fonds Duurzaam Funderingsherstel*) is available for homeowners, though not included in the model.

Results

Applying the model to the Achmea Mortgages portfolio shows that most properties are unaffected by pile rot. Homes built after 1975 are assumed to have concrete or deep foundations. Within the portfolio, around 18.1% of the total portfolio is at risk of either pile rot or differential settlement. 12.3% of the total portfolio is at risk of pile rot.

For pile rot, 12.1% of the total portfolio is expected to have a damage class between 1 and 3 by 2050 (see figure 4), meaning only limited damage. Just 0.2% of the total portfolio is expected to fall into damage class 4 or 5, showing that severe damages are extremely rare.

FIGURE 3: THE PART OF THE PORTFOLIO THAT COULD BE AFFECTED BY PILE ROT OR DIFFERENTIAL SETTLEMENT

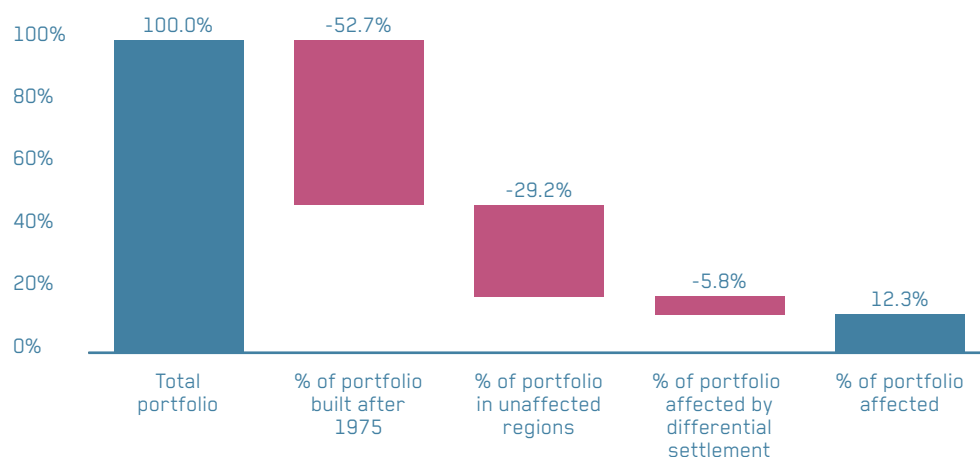


FIGURE 4: DISTRIBUTION OF DAMAGE CLASSES WITHIN THE ACHMEA MORTGAGES PORTFOLIO

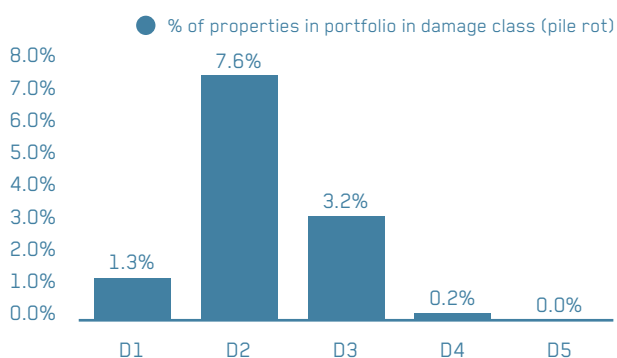
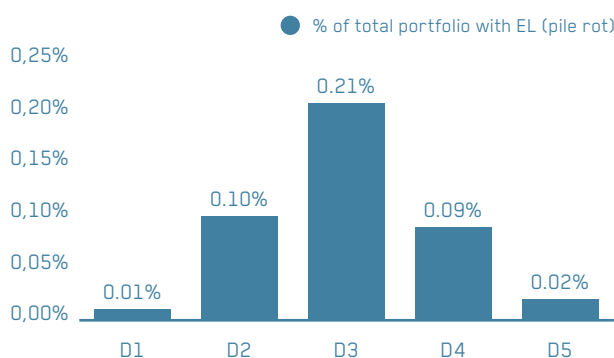


FIGURE 5: SHARE OF PROPERTIES WITH EL PER DAMAGE CLASS



As a share of the total Achmea Mortgages portfolio the number of properties with an EL due to pile rot is 0.4%. Taking into account the size of the EL the extra expected loss due to pile rot damage within the portfolio is 0.4 basis points over the lifetime of the mortgages.

Conclusion

Foundation damage from climate-related risks, such as pile rot, can cause substantial hardship for individual homeowners. In severe cases, repair costs may exceed €100,000 and temporary relocation may be required. The personal impact of such disruption is significant and should not be underestimated. However, the aggregate financial risk for mortgage investors remains limited.

In the Achmea Mortgages portfolio, only 12.3% of homes, typically built before 1975, may be susceptible to pile rot. Even among these, most affected properties are expected to experience only minor damage: 98% of pile rot cases fall into low damage categories.

Effective mitigation measures, including substantial loan-to-value headroom and the National Mortgage Guarantee, further contain investor exposure. Using Monte Carlo simulations and standard credit risk models, the expected loss for the portfolio is very low and is estimated to be around 0.4 basis points when accounting for probability of default.

While foundation damage issues are inherently more complex than financial models can fully capture, and data limitations create uncertainty at the individual property level, the large scale and diversification of mortgage portfolios help manage this uncertainty. To further reduce risk and support homeowners, Achmea Mortgages has expanded its green loan to include climate-adaptive measures alongside energy efficiency improvements. The climate-adaptive measures support foundation protection, water management, and other improvements that enhance resilience against drought-related foundation damage.

Overall, pile rot damage is a manageable risk at the portfolio level, though continued attention to early identification and targeted support for affected homeowners remains essential. The model provides valuable guidance on aggregate financial risk, even if individual property risk remains difficult to predict.

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