12th National Conference on Earthquake Engineering
Salt Lake City, Utah
27 June - 1 July 2022
Hosted by the Earthquake Engineering Research Institute

Simulating Post-Disaster Landlord Residence and Rental Unit Recovery

E. Mongold[1], R. Costa[2], Á. Zsarnóczay[3], and J. W. Baker[4]

ABSTRACT

Post-disaster housing recovery of rental units differs greatly from that of owner-occupied. There are fewer avenues for funding the repair of rental property. Moreover, if the landlord's home is damaged by the disaster, they will likely prioritize the repairs of their home, further delaying the repair of rental units. Existing housing recovery models have not accounted for the dependency between landlord and tenant homes. This study presents a model for the simulation of housing recovery such that rental units are connected to their landlord. We identify the residences in Alameda (CA) that are owned by landlords who also live in the city. We simulate housing recovery following a hypothetical *M*7.0 earthquake assuming landlords will repair their own homes before their rental units. The outcome of this model shows that at low damages the connection has little or no impact, but at high damage not accounting for the connection leads to over 20% error.

Introduction

Past disasters have demonstrated that recovery is not uniform across all populations. A well-documented case is the tendency of the rental building stock to be slower to recover than owner-occupied property [e.g. 1-3]. There are multiple reasons for this differential recovery: post-disaster recovery funding programs tend to favor owners [4]; renters lack the autonomy to decide what happens to their buildings; if landlord buildings are damaged, repairs to rental homes may not be prioritized. The dependency in the recovery of landlord-occupied and tenant-occupied homes is seldom captured in housing recovery models due to the unavailability of detailed data. Some recovery models only include owner-occupied property [e.g. 5-7]. Some models include renter-occupied buildings but assume the owners are not affected by the same disaster and will attempt to repair the unit soon after. Other models impose delays to the recovery of rental units with an increased impedance time for the owner to procure resources [8,9]. Some models are calibrated using empirical data, so delays are not seen as a result of factors included in the model [10].

This study employs a unique dataset that allows us to identify renter-occupied buildings which are owned by landlords who also live in the city. Our model adds onto previous work by connecting rental units to their

[1] PhD Student, Dept. of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305 (emongold@stanford.edu)
[2] Post-Doctoral Scholar, Dept. of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305
[3] Research Engineer, Dept. of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305
[4] Professor, Dept. of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305

Mongold, E., Costa, R., Zsarnóczay, Á., & Baker, J.W. Simulating Post-Disaster Landlord Residence and Rental Unit Recovery. *Proceedings of the 12th National Conference on Earthquake Engineering*, Earthquake Engineering Research Institute, Salt Lake City, UT, 2021.

landlords such that rental financing and repairs do not begin until the landlord completes financing or repairs on their own home. Thus, we can simulate the rental unit recovery as being dependent on its landlord. Recovery with and without accounting for connection to a specific landlord building are presented for five different portions of initially damaged buildings, taken from a suite of recovery simulations.

Methods and Data

Our renter recovery model builds onto an agent-based recovery model developed in previous work by the second author and detailed in [8]. For brevity, here we only describe the addition proposed in the current study. This addition includes a step in the modeling of rental unit recovery to check if their landlord's home is damaged, shown in yellow in Fig. 1. For a landlord to start procuring financing to repair their rental unit, their property must have either incurred no damage or have been repaired. In the case that a single landlord has multiple rental units, the units are randomly ordered and each one must wait for the previous unit to complete repairs before beginning financing. It is assumed that each landlord will repair all their units in time. We assume that the financing of rental units comes from bank loans.

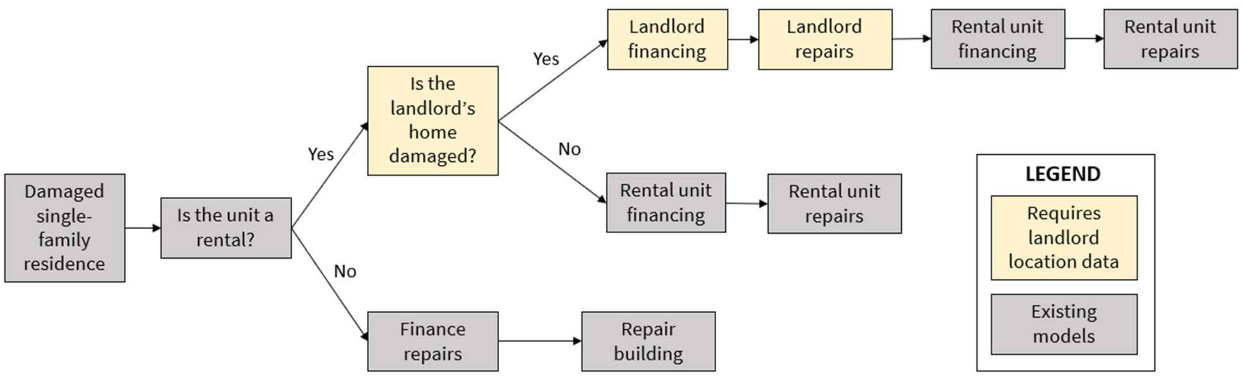

Figure 1. Flow chart of rental unit recovery based on landlord location, financing, repair times, and competition for construction crew resources. Yellow indicates additions in this study and grey are steps taken in existing models.

It is possible to employ this model due to detailed data available from the publicly available tax assessor database for Alameda, CA. To determine the landlord connections for each rental unit in the case study, we extracted the parcel address and mailing address for each parcel from the database. We assume that single-family housing units with mailing addresses which differ from their parcel addresses are rental units and the mailing address is the landlord's residence. Just over 17% of the residences fall into that category (Table 1). Of the mailing addresses attached to these units, more than half have an Alameda address. For this case study, only landlords within the city of Alameda are assumed to be affected by the earthquake, though it is possible that landlords incur damage in nearby cities. Of the 912 rental units with landlords within the city, 418 are single-family residential buildings for which we can model damage and recovery. Within that, 362 are unique landlords, so just over 13% of rental units with landlords in the city share a landlord with at least one other rental unit. In these cases, they not only wait to begin financing until their landlord completes repairs, but may have to wait for the repair of other rental units as well. Rental units with non-single-family landlord addresses are assumed to have high income landlords who begin financing the repairs immediately.

Table 1. Summary statistics of Alameda case study data.

	Number of buildings	Percent of row above
Single-family residences	9870	—
Rental units	1694	17.2%
Rental units with landlord in Alameda	912	53.8%
Rental units with landlord in single-family residence in Alameda	418	45.8%
Landlords in single-family residences in Alameda	362	86.6%

Case Study Results

We apply the expanded model to investigate housing recovery in the city of Alameda, CA following a hypothetical *M*7.0 earthquake on the Hayward fault. We ran the simulation using our proposed model as well as a baseline model which assumes no connections between rental units and specific landlords in the city. Two modeling approaches are used for comparison in the case study. The assumption with rental unit and landlord connections follows the model proposed in the previous section. This accounts for those rental units with single-family landlords in the city of Alameda waiting for their landlord to complete repairs on their own home before beginning the financing process for the rental unit's repairs. This is compared to a baseline model which assumes no connections between rental units and landlords. No delay is imposed on the rental units, such that their financing and repair process is the same as that of owner-occupied buildings, with the assumption that the landlord is a high-income individual.

These two modeling approaches are used to simulate 100 realizations of the *M*7.0 earthquake using the SimCenter's R2D tool [11]. That is, 100 realizations of ground acceleration, damage, loss, and repair time were produced for each building. For each realization, we simulated housing recovery for the following eight years. Our preliminary analyses indicated that the modeling approaches yield similar results if a small portion (e.g., < 20%) of the rental building stock is damaged. As damage is more wide-spread, accounting for the connection between the recovery of rental units and landlord units becomes more relevant. To highlight these findings, we present the results for 5 of the 100 simulations. These simulations are selected because they represent severe or complete damage to approximately 10, 20, 30, 40, and 50% of the rental units. We emphasize that these scenarios are not equally likely, i.e., the probability of observing damage to 50% of the buildings is smaller than the probability of observing damage to 10% of the building stock.

The recovery curves for the five scenarios shown in Fig. 2a exemplify the difference between repair trajectories with and without the renter-landlord connection. The curves start to differ at the 30% initial damage scenario, and those separations are seen for more damaging scenarios generally after about half of the rental units have been repaired. These curves are summarized by their recovery lengths in rental unit-days, which accounts for both the length of time to repair, as well as the number of units which are out of use over that time, or the area under the recovery curves. This captures the tail-end scenarios of few rental units taking many years to repair. Of the five simulations, once the initial percent of damaged rental units reaches 30%, there is a visible increase in the length of rental unit recovery time, with increasing effect as initial damage increases. The largest error in the presented cases, at 50% initial damage, is 23% underestimated by the simplified model excluding landlord-renter connections.

This study shows that in cases with increasing initial damages, accounting for rental unit connections to landlords increasingly affects the trajectory of rental unit recovery after an earthquake. The exact percentage of initial damage may be sensitive to other aspects of the case study, such as the proportion of landlords within the city or the availability of contractors; however, the effect of accounting for the renter-landlord connection is not negligible and should be further investigated to improve the ability of recovery models to support decision-making. With more complete data on landlord locations, the assumptions can be further reduced. The slower recovery of rental units comes as a result of the connections, without an imposed factor of longer recovery time for renters, as has been done in previous studies.

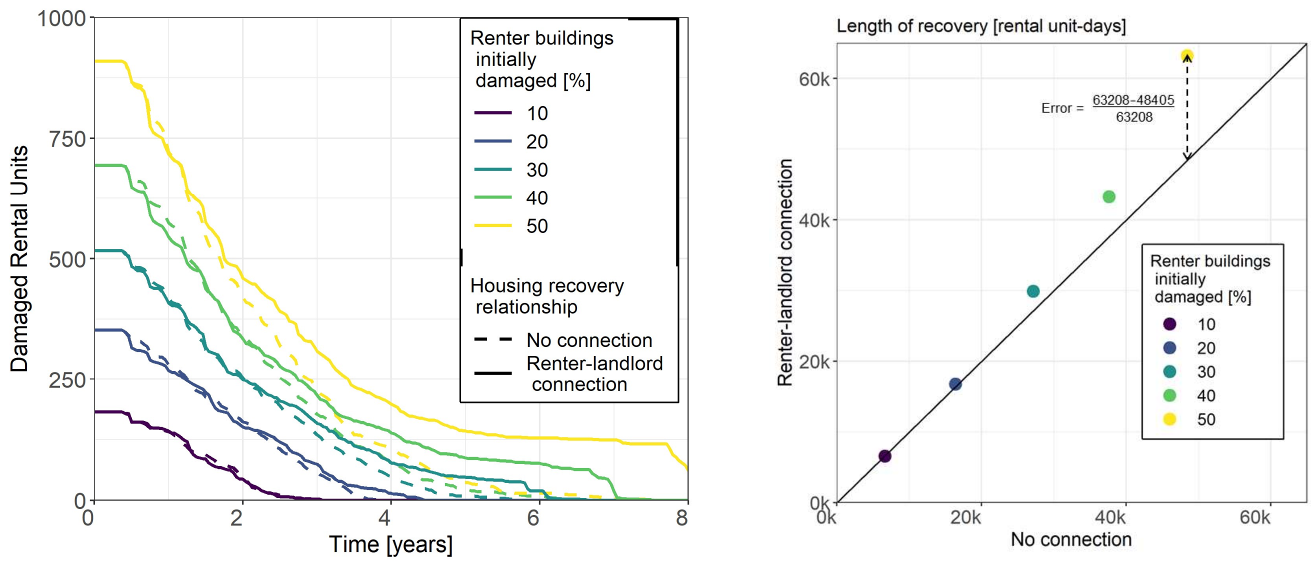

Figure 2. (a) Recovery curves for Alameda after five initial percentages of damaged rental units accounting (solid) and not accounting (dashed) for the connection between the rental units and their landlords' recovery. (b) Length of rental unit recovery (rental units x days) accounting for renter-landlord connections versus modeling without those connections.

Conclusions

A landlord makes decisions for their own residence as well as those that they rent out. Thus, the decisions made about each of their units are interconnected. We incorporate this dependency into an agent-based model under the assumption that landlords will fund and begin repairs on their own home before repeating the process for their rental properties. The results show slower recovery for rental units, especially in cases where substantial damage is observed to rental units, there is up to a 23% lower estimation of rental unit recovery times when excluding the renter-landlord connection in the model. Though the exact proportion of damage may depend on case-specific factors, this proves that with enough initial damage, the rental unit connection to landlords alters the trajectory of rental housing stock recovery. This disparity appears in our model as a natural outcome of the recovery process of their landlord and other rental units, unlike prior approaches that a priori imposed an arbitrary delay on rental unit recovery. Knowledge of landlord locations increases the ability of an agent-based model to predict the timing of recovery of rental units across the region and allows for continued improvement of these models.

Acknowledgments

Thank you to Nick Slavin and Joseph Rodgers for being a part of the conception of this project and working through a first implementation for our Anchorage, AK project.

References

1. Henry, J. (2013). "Return or relocate? An inductive analysis of decision-making in a disaster." *Disasters.* 37(2): 293-316. DOI: 10.1111/j.1467-7717.2012.01303.x.
2. Tafti, M.T. and R. Tomlinson (2013). "The role of post-disaster public policy responses in housing recovery of tenants." *Habitat International* 40: 218-224. DOI: 10.1016/j.habitatint.2013.05.004.
3. Peacock, W.G., N. Dash, Y. Zhang, and S. Van Zandt. (2018). "Post-disaster sheltering, temporary housing and permanent housing recovery." In *Handbook of disaster research 2nd edition,* 569-594. https://link.springer.com/chapter/10.1007/978-3-319-63254-4_27.
4. Mukherji, A. (2017). "Post-Disaster Housing Recovery." *Natural Hazard Science.* DOI: 10.1093/acrefore/9780199389407.013.82.
5. Sutley, E.J., and S. Hamideh. (2018). "An interdisciplinary system dynamics model for post-disaster housing recovery." *Sustainable and Resilient Infrastructure.* 3(3): 109-127. DOI: 10.1080/23789689.2017.1364561.
6. Moradi, S. and A. Nejat. (2020). "RecovUS: An Agent-Based Model of Post-Disaster Household Recovery." *Journal of Artificial Societies and Social Simulation* 23(4): 13. DOI: 10.18564/jasss.4445.
7. Miles, S.B. (2018). "Participatory Disaster Recovery Simulation Modeling for Community Resilience." *Int J Disaster Risk Sci.* 9:519-529. DOI: 10.1007/s13753-018-0202-9.
8. Costa, R., T. Haukaas, and S.E. Chang. (2021). "Agent-based model for post-earthquake housing recovery." *Earthquake Spectra* 37(1): 46-72. DOI: 10.1177/8755293020944175.
9. Miles, S. B. (2017). "DESaster: A discrete event disaster recovery simulation built on top of the Simpy discrete event simulation Python library." Available at: https://github.com/milessb/DESaster.
10. Miles, S.B., and S.E. Chang. (2011). "ResilUS: A Community Based Disaster Resilience Model." *Cartography and Geographic Information Science.* 38(1):36-51. DOI: 10.1559/1523040638136.
11. McKenna, F., S. Gavrilovic, Á. Zsarnóczay, K. Zhong, & W. Elhaddad. (2021). NHERI-SimCenter/R2DTool: Version 1.1.0 (Version v1.1.0). Zenodo. DOI: 10.5281/zenodo.5033626.
12. Alisjahbana, I., A. Moura-Cook, R. Costa, and A. Kiremidjian. *In Review.* "An Agent-based Financing Model for Post-Earthquake Housing Recovery: Quantifying Recovery Inequalities Across Income Groups."