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Initial Perceptions of Remote Virtual Inspections in the Residential Construction Industry Sector

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The COVID-19 pandemic created a new set of restrictions and safety protocols for the residential construction industry. Many jurisdictions began placing social distancing practices on building inspectors, limiting their ability to visit the jobsite. This adjustment required residential contractors and inspectors to adapt to virtual inspections using videotelephony, photographs, or recorded videos. As this inspection method gains traction in the residential industry, questions arise regarding its benefits, drawbacks, and industry acceptance. This case study analyzes the perceptions and experiences of five separate homebuilders in Yolo County, California. Semi-structured interviews were conducted with five residential general contractors, transcribed, and thematically analyzed to discover reoccurring patterns and ideas. Throughout the interviews, six significant themes emerged including familiarity with the technology, time and cost impacts, applicability, accuracy, homebuilders' preference, and future considerations. Based on the interviews, homebuilders believe the new technology has potential time and cost savings. There are some concerns with the technology's accuracy as virtual inspections can inhibit the inspector's visibility, in certain scenarios. However, all general contractors interviewed agreed they would like to see a hybrid system in the future that allows for virtual and in-person inspections, and also agreed that not all items are appropriate for remote inspections.

Key Words: Remote Virtual Inspections, Homebuilders, Industry Perception, Construction Industry, Technology

Introduction

As the COVID-19 pandemic spread throughout the United States, many states, counties, and cities completely closed and began enforcing work-from-home mandates to slow the spread of the virus. Although many industries required workers to stay home, California's governor issued Executive Order N-33-20 on March 19, 2020, allowing essential workers to return to work. "Construction workers who support the construction, operation, inspection, and maintenance of construction sites and construction projects" (California For All, 2021) were considered part of the essential workforce, allowing workers, inspectors, and operators to continue working on construction sites, following strict safety protocols for social distancing.

Although construction continued throughout California, many jurisdictions, especially those with high disease transmittance, enforced stricter guidelines on workers and construction sites, stopping all non-essential work. Residential construction remained essential since it was "necessary to maintain safety, sanitation and economic security" (NAHB Now, 2020), with 78% of builders reporting being classified as essential businesses in their geographical area (NAHB Now, 2020). However, many authorities having jurisdiction (AHJs) switched to remote work only, leaving AHJs and builders to develop a solution to inspect ongoing construction without having an inspector physically onsite. In response, the industry quickly adapted existing technologies to conduct remote virtual inspections on projects deemed essential, such as housing, so construction could continue uninterrupted while still following social distancing mandates.

In Yolo County, California, the building inspection services department allowed remote virtual inspections to reduce the number of in-person inspections (Building Inspection Services, 2020). Since inspectors were considered essential workers, homebuilders and inspectors could opt for virtual inspections for their projects. This study analyzes the preliminary perceptions of five residential general contractors located in Yolo County, California regarding the implementation and effectiveness of remote virtual inspections for new residential construction.

Literature Review

The COVID-19 pandemic was shown to have a noticeable adverse effect on homebuilders, as detailed in Figure 1, with 82% of respondents indicating that building departments took longer than normal to respond to requests for inspections (Emrath, 2020). With the median number of separate inspections conducted during the construction of a typical single-family home being eight, and 17% of builders using more than fifteen inspections (Emrath, 2013), delays to timely inspections can adversely impact a company's profitability.

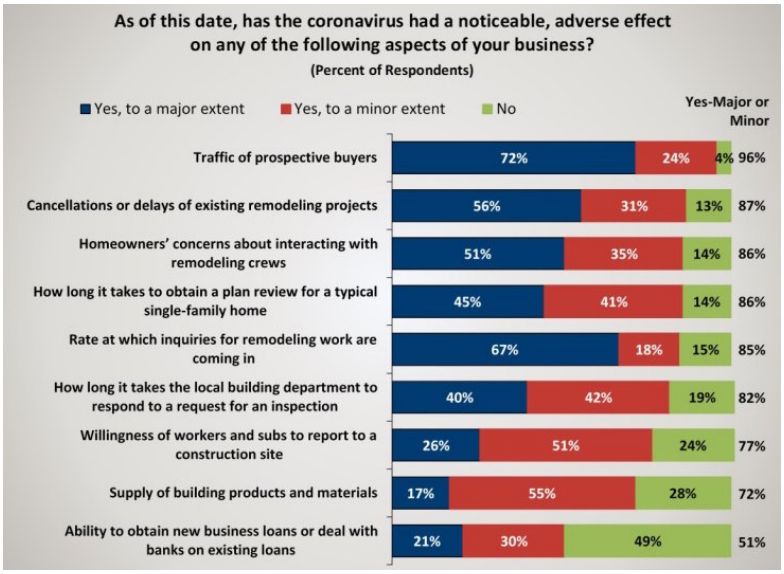

Figure 1: Impact of COVID on Homebuilders. Reprinted from *Virus Now Impacting Traffic for Nearly All Builders*, by Emrath, P., 2020.

To help alleviate this problem, AHJs began to allow the use of third-party private inspections and virtual inspections. As defined by the International Code Council (2020), remote virtual inspections (RVIs) are a "form of visual inspection with uses of visual or electronic aids to allow an inspector or team of inspectors to observe products and/or materials from a distance because the objects are inaccessible or are in dangerous environments, or whereby circumstances or conditions prevent an in-person inspection" (International Code Council, Inc., 2020). In a survey conducted by the National Association of Homebuilders (NAHB) shortly after the pandemic started, 20% of builders stated their local building department adopted the use of RVIs specifically as a response to the pandemic. Prior to the pandemic, only 4% of AHJs used virtual inspections as standard practice (NAHB Now, 2020), as shown in Figure 2.

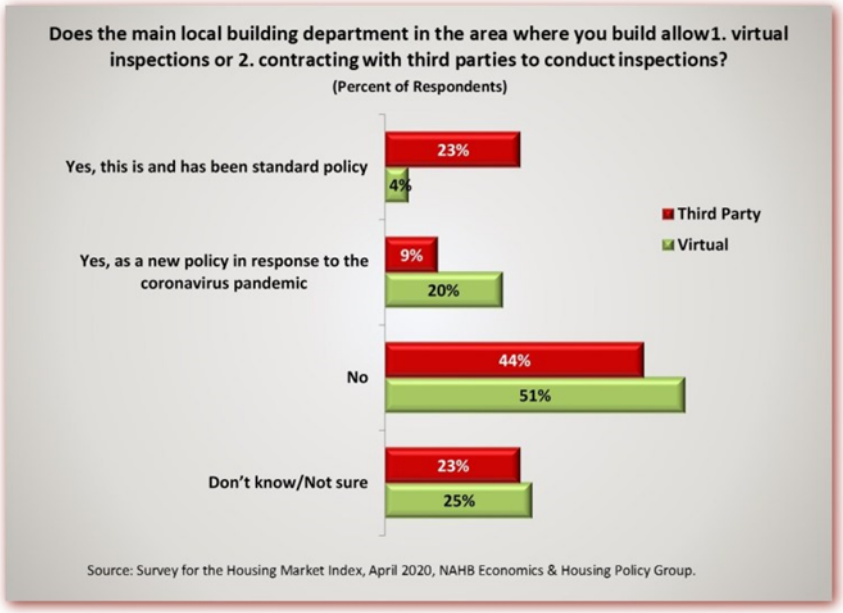

Figure 2: Use of Virtual or Third Party Inspections for Residential Builders. Retrieved from *Some Cities Keep Construction Going Via Virtual Inspections*, by NAHB Now, 2020.

Much of the research regarding RVIs focuses on the development of technologies for unmanned remote inspections of existing facilities to determine anomalies or defects in hard-to-access or high-risk areas, such as the magnetic tomography inspection method for Arctic offshore pipelines (Kamaeva, Kolesnikov, Eremin, & Khusnutdinov, 2019) or the development of unmanned augmented virtual reality for remote inspection of electrical power substations (Mattioli, Cardoso, & Lamounier, 2020). Alternatively, researchers theorize and advocate for digitized systems within the construction industry to facilitate remote inspections, including the widespread use of building information modeling and digital twins (Rotilio & Tudini, 2020) as part of the new industry paradigm Construction 4.0 (Munoz-La Rivera, Mora-Serrano, Valero, & Onate, 2021). However, these technologies have not been fully developed or realized and require substantial investment in time and resources to use for RVIs.

Since these technologies have not been fully tested, and the pandemic happened so abruptly, the construction industry needed low-technology solutions that could quickly and easily be implemented at the field level. Turning to smartphones and small electronic devices, RVIs were a quick solution

that could include live-video chats in real-time using videotelephony, recorded videos, or photographs sent to the inspector via email, text message, or an online submission platform. The goal of this paper is to discuss how Yolo County, California, implemented specific technologies to address the need for RVIs. Current research to date does not focus on RVIs in residential construction and this study seeks to analyze the initial perceptions of homebuilders regarding the implementation of RVIs within Yolo County, California.

Methodology

A qualitative data approach was utilized to better understand the detailed perceptions of the participants. Following Polkinghorne's (1989) recommendations for the number of interviews to understand a specific phenomenon, five residential homebuilders were selected to participate in a semi-structured interview to review their perceptions of virtual inspections in the workplace. Each participant held an ownership position at their respective company. The companies were individually selected to fit the criteria requirements defined below.

1. Must be a residential general contractor
2. Must have less than 100 employees
3. Must be located in Yolo County, California
4. Must have some knowledge of virtual inspections

Interview Structure

Semi-structured interviews were recorded over the phone and transcribed. The interviewer did not follow a strict formalized list of yes or no questions; rather several broad, open-ended questions that led to follow-up questions were used, allowing the participants to describe their experiences, following a phenomenological approach (Creswell & Poth, 2018). This semi-structured approach allowed the participants to highlight their perceptions and provide details of their own experiences. The open-ended questions that acted as the framework for each interview are shown below.

- What are some of the benefits of virtual inspections in the residential sector?
- What are some of the disadvantages of virtual inspections in the residential sector?
- When are virtual inspections appropriate to conduct over the traditional method?
- Do you have any concerns with the accuracy of virtual inspections?
- If COVID-19 was not a factor, would you prefer to use in-person inspections or virtual inspections?
- Do you think this technology will take off in the next decade or do you think we are going to see less after the pandemic?

Coding and Data Analysis

The interviews were transcribed digitally to allow for coding and data analysis. Using Charmaz's (2012) initial coding approach as a framework, the data collection was performed inductively as the homebuilder's ideas were analyzed to find industry themes. The transcriptions were labeled with codes using ATLAS.ti Cloud. Once all transcriptions were coded, reoccurring patterns were grouped to determine emergent themes from the interviews, following Saldaña's (2021) coding methods, identifying common and divergent ideas presented by the different interviewees. These themes were

then sorted into three larger categories: (1) benefits of RVI, (2) disadvantages of RVIs, and (3) future considerations.

Results and Discussion

All five interviews were digitally transcribed and coded to find reoccurring themes and ideas. Throughout the five interviews, six significant themes emerged. These six themes included (1) familiarity with virtual inspections; (2) time and cost impact; (3) applicability; (4) accuracy; (5) homebuilders preference; and (6) future considerations. While several homebuilders had differing opinions over the implementation and use of virtual inspections, most participants agreed on these six topics. Each theme is expanded upon in the sections that follow.

Familiarity with Virtual Inspections

At the time of the interview, all five residential general contractors had used some form of RVIs, but only two had encountered virtual inspections prior to the pandemic. COVID-19 contributed to the major shift of virtual inspections, where each participant noted they saw a dramatic increase in virtuality. One participant noted, “we have gotten permission in the past to take photographs of the work when it’s a jurisdictional holiday, and the inspector could not make it.” Even though some companies used virtual inspections prior to the pandemic, they were only used in special circumstances and were not the industry standard.

As a result of COVID-19 and social distancing requirements, all five participants transitioned to RVIs on each of their projects. Two participants used only still pictures, taking photographs of items on-site and sending them to the inspector; the remaining three utilized a combination of videotelephony and still pictures.

Time and Cost Impact

All participants agreed that RVIs impacted both time and cost for the general contractor. Some participants stated that time is saved while others disagreed stating that minor inspections required additional resources to complete an RVI.

The interviewed general contractors perceived that time savings occurred for both themselves and the county. For the general contractor, there was less waiting time for the inspector to arrive on-site and, once on site, there was less trivial conversation with the inspector. One contractor elaborated on time savings when he said, “we don’t have to wait around for the inspector to show up. When an inspector comes, we usually need a body on site, and that employee is sitting around doing nothing while he waits.” Another participant agreed by saying, “I usually take pictures before I leave the jobsite, and it takes me five minutes tops. Inspectors talk your ear off, and the inspection can sometimes take close to an hour.” This efficiency provides not only times savings, but also cost savings for the contractor. One participant said, “There will definitely be cost savings. In the past, employees have waited for inspectors for hours, and that employee is on the clock. So, you’re going to save money from that perspective.” Furthermore, another homebuilder mentioned that the time savings made by the virtual inspections directly correlate to costs savings for both the general contractor and the county.

In addition to time savings for the general contractor, all five interviewees mentioned that virtual inspections provide tremendous time savings for the county. With virtual inspections, inspectors don't have to drive around the county and, instead, can inspect a building from their office. Less drive time means they can complete more inspections during a single day.

One contractor had a different perspective, saying more minor virtual inspections can waste time and resources. He said, "on smaller inspections, we do not have to be onsite, and the inspector can perform his task alone. When we do a virtual video-call inspection, we have to be onsite and point the camera around for him to see, which costs us time." This contractor also stated that cost savings apply only to the AHJ, and the general contractor may experience a financial loss due to this added time spent on minor inspections. In addition to time, he also stressed the importance of having in-person inspections as he stated, "there has been a couple of times where a building inspector has called something that we genuinely missed, and I am so thankful because that correction has saved me a lot of money and headache." While these mistakes don't happen frequently, they are more likely to be caught in person and can save the general contractor a financial loss.

Applicability

All five homebuilders agreed that virtual inspections work better in some scenarios but worse in others. Three participants mentioned how virtual inspections should be used for smaller items and in-person inspections should be used for larger items. One participant said, "virtual inspections work best for smaller items such as drywall nail inspection or insulation inspection. When it comes to larger-scale items like roof, foundation, and MEP [mechanical, electrical, plumbing], I think it's more likely that things could get missed." Another homebuilder mentioned that virtual inspections should only be used for items that are exposed. He went on to say, "Framing, mechanical and electrical are all extremely important inspections because once they get buried, it becomes really difficult to get to and fix. Whereas if you miss something and it's exposed, at least we've caught it." The third participant noted that virtual inspections work best in scenarios where you can prove the accuracy of the dimensions. He went on to mention, "I think virtual inspections work in scenarios where you have to confine to a certain set of dimensions. You can use a tape measure in those types of applications to show that you are meeting that requirement. It might get a little bit more difficult when you have to actually test things like electrical, safety and plumbing items." Based on these responses, the general contractors believe that RVIs work best only in specific applications, and should not completely replace in-person field inspections.

Accuracy

Four of the five homebuilders believed that virtual inspections are less accurate than in-person inspections. One participant noted, "If you're not getting a set of eyes physically on something, there are going to be more mistakes." He went on to say, "One example that has been hard to do virtually is when they are inspecting shear nailing for instance, they want to see if that nail has penetrated layers in plywood and it's hard for the project manager to take an accurate picture of that instance." Several participants also noted how virtual inspections contribute to an increase in ethical abuse. One participant mentioned, "I get the general impression that the inspector would rather be on the job, and it's a trust issue. They don't trust us. Anybody can manipulate the camera, and I've heard some inspectors say that general contractors have been manipulating pictures and videos to speed up the process." Another homebuilder agreed with this abuse by saying, "A lot of GCs [general contractors] try to schedule a rough inspection on a Friday afternoon because they know the inspector is going to be looking forward to the weekend and not pay as much attention. And so there's always been

strategies like that to make things easier, but this one, I suppose, would be open to more abuse." One homebuilder also mentioned his concern for legal repercussions by stating, "I am concerned with some of the liability issues that might come up down the road if something was missed because it wasn't thoroughly inspected. As an owner of the company, I want to take every precaution possible to minimize legal repercussions."

In contrast, one participant made the argument that virtuality does not affect the accuracy of the inspection. He went on to say, "I don't think it affects the accuracy. I think [virtual inspections] could be just as effective if the inspector knows what to look for and is shown the proper footage. It's an odd thing anyway for them to come out here for 15 minutes and think they can find everything in a 6,000 square foot house."

Homebuilders' Preferences

Each participant was asked if they wanted to keep a form of virtual inspection post-pandemic. All five homebuilders agreed they would like to keep the technology in some circumstances. For example, one participant noted, "I would like to see a hybrid model in the future; the kind where you need to have an inspector on site when it's really critical for them to be there. But virtual inspections on some of the smaller things, that you can document easily and send to inspector would be beneficial." Another homebuilder agreed by saying, "virtual inspections are not as good as in-person inspections, but I suppose I would want to keep the option open for smaller projects."

Two participants noted they would only want to keep one form of the technology used for RVIs. One homebuilder mentioned, "If I had the option, I would want to keep virtual inspections using the picture method just because of the convenience factor, and then I don't have to chat with them for 15 minutes." Another participant mentioned how he would only want to keep the video chat, like FaceTime, method of virtual inspections; "FaceTime did work well in Yolo County. I'm on the jobsite, and I'm able to flash my iPad around, and he would say point me up over there. So FaceTiming is the best and if COVID wasn't a factor, I would want to keep that method."

Future Considerations

All five homebuilders agreed that the use of virtual inspections will grow in the residential construction sector. One participant said, "I think it's going to be more in use, and I think the technology is going to be better. I just think the Zoom calls are going to evolve, and that's not going away. We are going to refine this and make it more effective." Another participant agreed by saying, "I see this hybrid model working to our advantage and taking off in the future." He went on to say, "With the change in technology and the way that the digital era is going, it's going to be beneficial, and I think it's going to go in that direction. I truly believe there will be a hybrid model that would have the inspector come to certain critical inspections or larger structural inspections. But for the residential sector, I think it makes a lot of sense, especially if it's something simple."

Another participant saw the potential of the technology but was hesitant about the implementation. He said, "I think jurisdictions would be smart to adopt some kind of hybrid model. And that being said, if it makes sense, and would save money, then the government probably won't do it." One homebuilder also mentioned the technology can grow but never replace humans; "I think in-person inspections has a level of fluidity that is impossible to accomplish with technology." Even though these two participants were hesitant about future growth, they both agreed that a hybrid model would be more favorable. The uncertainties centered on implementation and complete virtuality.

Conclusion

This study analyzed the preliminary perceptions of five residential general contractors located in Yolo County, California, regarding the implementation and utility of RVIs for new residential construction. A majority of the contractors interviewed perceived that virtual inspections save time for both the general contractor and the inspecting agency. However, one homebuilder mentioned that there are reduced time savings for the general contractor during minor inspections when the general contractor must be onsite to video chat with the inspector. In cost savings, most participants believed that virtual inspections save both the general contractor and the AHJ money. However, one opposing theme was that RVIs may not be as thorough as on-site inspections, which could result in major items being missed, resulting in future repair costs.

All five participants agreed that virtual inspections should only be used in certain situations. These situations include smaller trades along with inspections that don't require testing. There was also a majority consensus that virtual inspections are less accurate than in-person inspections. The accuracy concerns include its susceptibility to abuse, the inspector's lack of vision, and the inability to take accurate photographs. Despite the accuracy concerns, all five general contractors agreed that they want to keep a form of virtual inspection and believed the technology will continue to grow in the future. This study was an in-depth analysis of five specific companies in the Yolo County area but does not accurately reflect the entire industry perception or the inspecting agency's perspective.

Future research could expand this study beyond initial perceptions in one geographical area, and explore homebuilders' perception of RVIs throughout the residential construction industry. Additionally, future research could further explore some of the themes presented, including time and cost impact, types of inspections that are better suited for RVIs, ethical implications, accuracy of inspections, or adoption of RVIs and standard practices developed by AHJs.

References

Building Inspection Services. (2020). "Yolo County." *Building Inspection Services | Yolo County*, www.yolocounty.org/government/general-government-departments/community-services/building-inspection-services.

California For All. (2021, September 22). *Essential Workforce*. https://covid19.ca.gov/essential-workforce/

Charmaz, K. (2012). *Constructing Grounded Theory* (2nd ed.). London: Sage.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative Inquiry and Research Design: Choosing Among Five* Approaches. Los Angeles: Sage.

Emrath, P. (2013, October 2). NAHB Eye on Housing. *Amid Cutbacks, Construction Inspections Are on the Rise*. https://eyeonhousing.org/2013/10/amid-cutbacks-construction-inspections-are-on-the-rise/

Emrath, P. (2020, April 9). *Virus Not Impacting Traffic for Nearly All Builders*. https://eyeonhousing.org/2020/04/virus-now-impacting-traffic-for-nearly-all-builders/

International Code Council, Inc. (2020, May). *Recommended Practices for Remove Virtual Inspections (RVI)*. http://media.iccsafe.org/2020_MarComm/Remote_Video_Insp_FINAL_w_Covers.pdf

Kamaeva, S. S., Kolesnikov, I. S., Eremin, N. A., & Khusnutdinov, L. A. (2019). Remote insepction by the magnetic tomography method (MTM) to prevent the risks imposed by exploitation of Arctic offshore pipelines. *IOP Conference Series: Materials Science and Engineering*, 1-10.

Mattioli, L., Cardoso, A., & Lamounier, E. (2020). 2D-3D Spatial Registration for Remote Inspection of Power Substations. *Energies*, 1-24.

Munoz-La Rivera, F., Mora-Serrano, J., Valero, I., & Onate, E. (2021). Methodological-Technological Framework for Construction 4.0. *Archives of Computational Methods in Engineering*, 689-711.

NAHB Now. (2020, March 28). *DHS Designates Residential Construction as 'Essential Infrastructure Business'.* https://nahbnow.com/2020/03/dhs-designates-residential-construction-as-essential-infrastructure-business/

NAHB Now. (2020, April 22). *Some Cities Keep Construction Going Via Virtual Inspections.* https://nahbnow.com/2020/04/some-cities-keep-construction-going-via-virtual-inspections/?_ga=2.19283453.439816919.1636572877-1418192254.1633123606

Polkinghorne, D.E. (1989). Phenomenological Research Methods. In R.S. Valle & S. Halling (Eds.), *Existential phenomenological perspectives in psychology* (pp. 41-60). New York, NY: Plenum Press.

Rotilio, M., & Tudini, B. (2020). The role of digitization in post-disaster reconstruction. *Geoinformation for Disaster Management* (pp. 125-130). Sydney: The International Archives of the Photogrammetry, Remote Sensing, and Spacial Information Sciences.

Saldaña, J. (2021). *The Coding Manual for Qualitative Researchers*. Los Angeles: Sage.