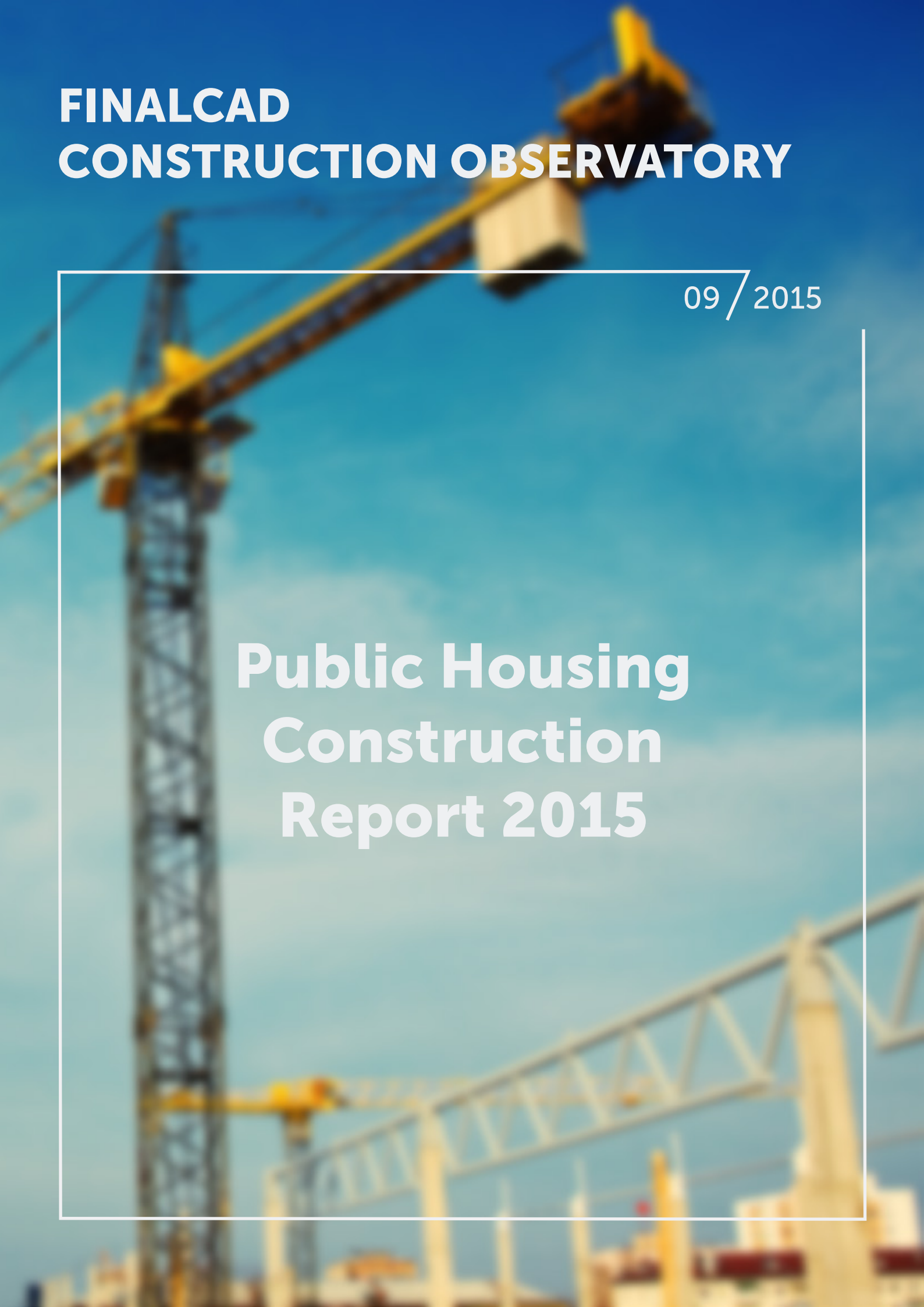
FINALCAD
CONSTRUCTION OBSERVATORY

09 / 2015

Public Housing Construction Report 2015



EDITORIAL

The economic crisis we have been experiencing for several years has had heavy consequences on the construction world. Restricted orders, prices falling below actual costs with the disappearance of companies, including highly experienced ones and the loss of skilled jobs has led to lower construction quality and an increase of ten-year warranty claims. As long as skilled workers are lacking, the projected reestablishment of the economy will not improve construction quality if we do not take care of things now, especially at client level.

With ambitious energy performance goals and increasingly complex construction rules, the cost-quality-schedule equation for projects has become more and more difficult to resolve. It has become essential to share experience and information among all disciplines in the industry in order to locate and precisely calculate mistakes, anticipate potential issues and to define methods to prevent and correct these issues as soon as possible which are understood and accepted by everyone (including clients, designers, project managers, contractors, subcontractors and final occupants).

For over 30 years, the Construction Quality Agency has aimed to anticipate problems in construction resulting from ten-year warranties. With this goal, it has developed an observatory with several tools known to and used by professionals, especially insurers. They have been particularly aligned to acknowledge accidents resulting from ten-year warranty issues. However, it has never developed an observation system for defects noticed prior to project close-out or during the final completion warranty period. FINALCAD has done this.

This report is the FINALCAD Construction Observatory's very first study. It provides an especially in-depth analysis based on information gathered that any powerful yet easy-to-use computer system can do. This remarkable tool will considerably improve awareness and consequently spur workers to improve construction finishing standards. Since 2011 this unique and systematic method has been used to collect data and focuses on the reliability of the data, its structure and ease of entry.

Published for the 76th Public housing Union Convention, this study provides a snapshot and a new approach to the quality of finished construction in public housing. It is even more relevant now that the "social lessor" client has been identified by the CQA as the least troublesome. The study is based on an analysis of observations made during work delivery operations, a unique time when the expected and actual level of service meet and the smallest discrepancy is a strong indicator of quality. Using a database of more than one million observations collected from about 30,000 homes, this analysis outlines the level of demand in the profession experienced daily. The deployment of collaborative, mobile solutions has helped to procure structured information directly from the field from more than 700 workers including architects, construction contractors and subcontractors. This raw data collected from operational observations paints a picture which is accessible to everyone involved and remarkable for its level of reliability. As long as the correlation between the quality of completed work and overall building quality can be highlighted (and includes only a small number of issues with ten-year warranties), this project should interest the Action Program for the Construction Quality and Energy Transition (PACTE). Since this study is the first illustration of the analysis potential offered by data gathering that FINALCAD has been able to achieve, its authors deserve congratulations.

Philippe ESTINGOY
General Manager of the Construction Quality Agency

Credit: Photo AQC

SUMMARY

ABOUT FINALCAD

FINALCAD, from mobile app to the Construction Observatory

Created in 2011, FINALCAD has helped to make progress in the digital transition in the world of public sector construction by rationalizing and industrializing the construction, renovation and operational phases. By digitizing processes prior to project close-out and final completion, the FINALCAD mobile app aggregates numerous observations collected on the field by its users.

From the start, the data entered into FINALCAD have been analyzed and categorized by self-scalable algorithms. Since it is anonymized, it helps to establish trends in terms of quality, productivity and priority attention areas in order to improve the operational excellence of all stakeholders in the field.

So, in addition to supporting workers in the construction field in their digital transition, FINALCAD has a unique point of view as a neutral observer of the standard practices in construction.

The FINALCAD Construction Observatory has focused on regularly publishing the status of completed construction quality for different types of work. Every stakeholder can benefit from this, particularly:

• Construction firms, designers, project managers and clients, who can become aware of the level of demand in the sector and compare themselves to the national average;

• Insurers, who may be interested in the correlation between completion quality and the reduction of issues resulting from completion warranties;

• Public stakeholders, who can better serve their markets by being aware of the operational expertise of the various people involved;

• Finally, the entire industry by contributing to cross-company exchanges in order to set up an action plan that will improve quality levels.

This study devoted to public housing is the first to be published by the FINALCAD Construction Observatory. Its goal is to give an outline of the quality standards in public housing construction in France by offering a map of observations identified during delivery operations.

We hope you enjoy reading it.

Jimmy LOUCHART
Co-founder & President of FINALCAD

INTRODUCTION

When constructing a home, professionals file through one after the other, often with no company intervening several times in the same place. This absence of re-intervention explains most of the defects identified when projects are delivered.

When taken individually, these defects often correspond to shortcomings in completion or even in minor works. Their magnitude requires alot of time and energy to identify and correct them.

Such shortcomings, which may seem inconsequential initially (such as defects relating to leaky air ducts), will develop over time, and in the most extreme cases, generate issues affecting a completion warranty by making the construction unusable (leaky air ducts void a home's airtightness through the presence of airgaps).

In other words, some of these defects may have a "butterfly effect," with often heavy consequences on the timeframe or cost of the construction and operation.This study aims to identify the most recurring defects for public housing by relying on factorial and statistical analysis. The challenge is to properly integrate these observations starting in the design phase of works with the ultimate ambition of increasing the sustainability and quality of housing by dealing with problems at the source.

Study outline

The first part of this report defines the sample from which the results were obtained.

The second part presents the results of the study and the most recurring defects, category by category.

The conclusion presents the implementation method as well as projected future studies of the FINALCAD Construction Observatory.

SCOPE OF THE STUDY

30,000 homes

1 million observations

500,000 photos

7,000 users

Geographic distribution

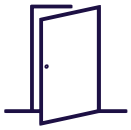
DISTRIBUTION OF OBSERVATIONS PER CATEGORY

Out of all the punchlists issued throughout project close-out operations, only observations identified in the residential areas were studied in this report. One million observations were categorized into 12 generic categories.

The distribution of observations in each of these categories is not homogenous. Three of the categories alone account for 63% of the observations: painting, plumbing/HVAC and interior joinery. Out of these three leading categories, painting accounts for the most observations, with 36% of the total. A second set was then identified by defining categories accounting for between 2 and 10% of the observations: electrical, exterior joinery (wood/plastics/composites), soft flooring, hard flooring (including tiling), partitioning (including suspended ceilings) and cleaning. Finally, three categories feature a small number of observations made (less than 2%): ironwork, metalwork, sealing (airtightness/waterproofing) and carpentry (built-in fixtures).

Paintwork
36%

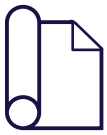
Plumbing
15%



Interior joinery
12%

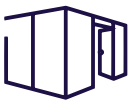
Electricity
9%

Exterior joinery/glazing
8%



Soft flooring
6%

Hard flooring
6%

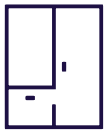


Partitioning
3%

Cleaning
2%

Metalwork
1%

Sealing
1%



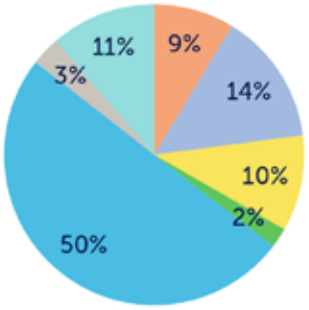
Carpentry
1%

INSIGHTS FROM THE STUDY

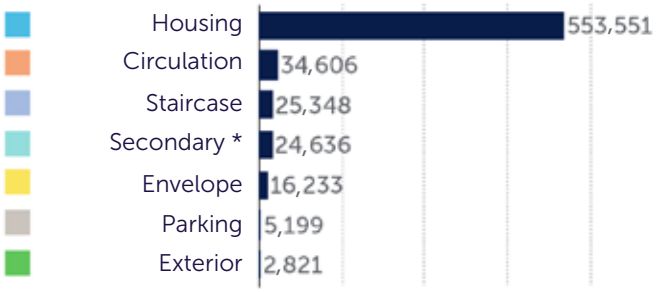
Homes are the most affected

Residential areas, making up 50% of the study's area, are the most affected, with 84% of the observations.

38k zones sorted by type



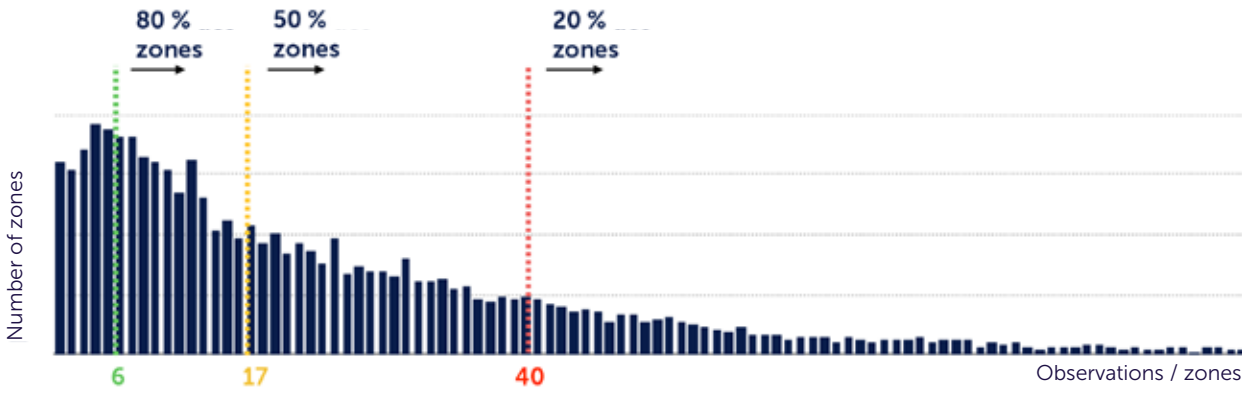
Observations sorted by zone type



* ; Basements, loft, stroller storage, mechanical room

A high-quality niche (top 20% of the least affected areas) account for less than 6 observations

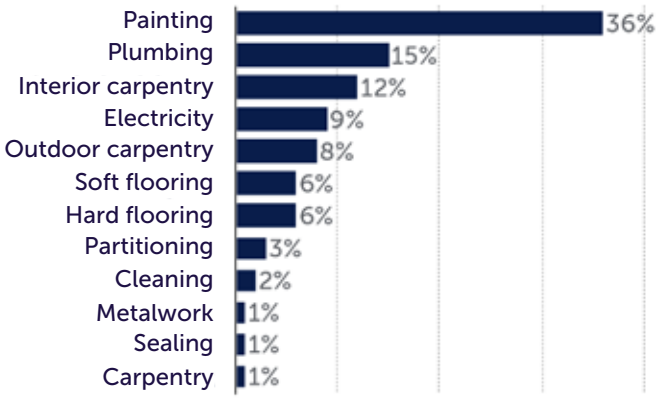
20% of the areas studied have fewer than 6 observations. Half of the areas have fewer than 17 observations. Areas having more than 40 observations make up 20% of the most affected areas.



Painting, plumbing and indoor carpentry are the most affected categories in homes

Representing respectively 36%, 15% and 12% of the observations gathered, painting, plumbing and carpentry account for 63% of the observations gathered in homes.

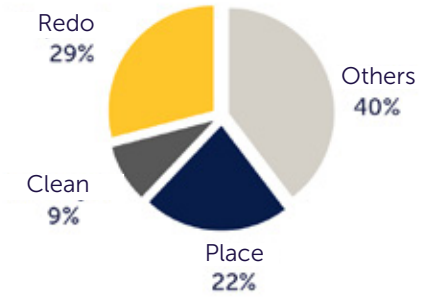
Distribution of observations per category



INSIGHTS FROM THE STUDY

In the delivery phase, shortcomings in work remain significant

Cross-analysis of the categories of action verbs reveals three pillars: redo, clean and instal. 63 other entries (align, empty, screw, etc.) were identified, but none of them go above 5% of the observations. Although reservations more often involve work to be redone rather than missing work, accounts for nearly ¼ of the observations.



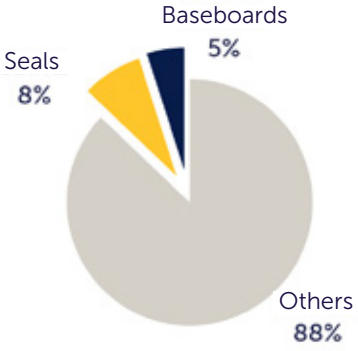

Redo


Place


Clean

Seals and baseboards account for the most observations out of all the items observed

The observations gathered refer to defects in more than 300 different items (faucets, shutters, doorknobs and partition walls). Although 92% of them represent less than 1% of the total volume of observations, two items stand out in the group: seals and baseboards.




Example: redo seal


Example: redo baseboard

The same defects everywhere

The study of the observation photos show that the same defects are found almost inevitably from one home to another. The following picture illustrates the "Reposition outlet" defect. The standard "Outlet never adjacent to the intersection of two walls" can be easily communicated, however.

« 17 defects per housing on average »

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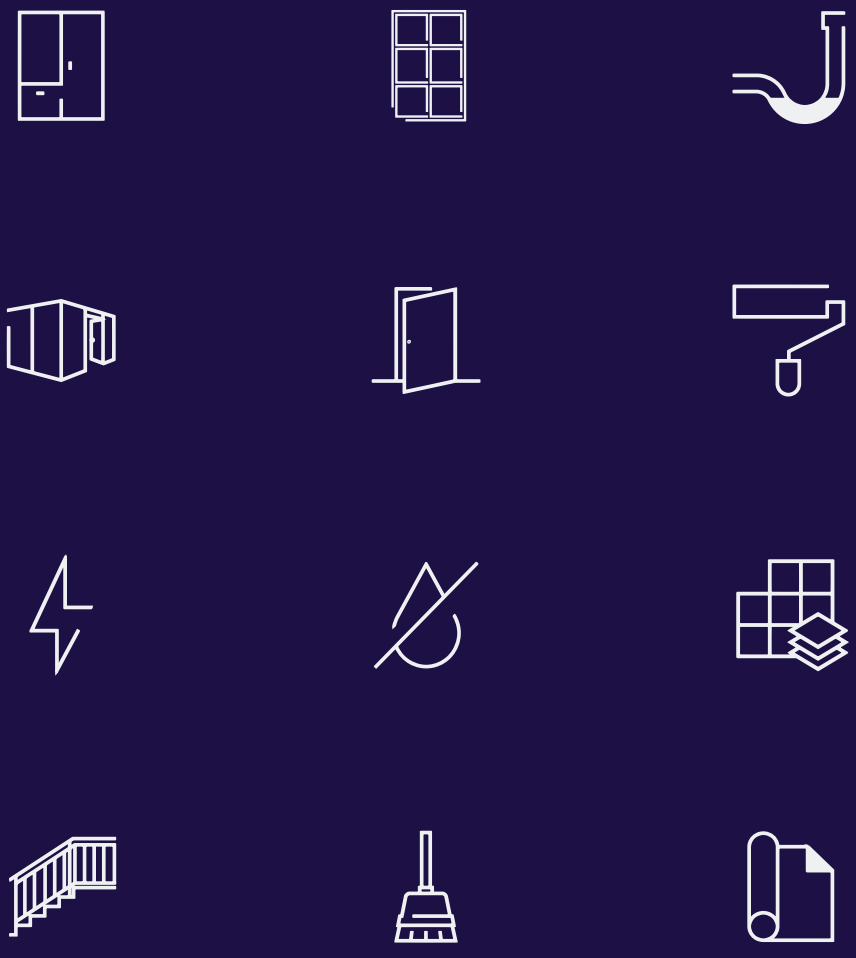
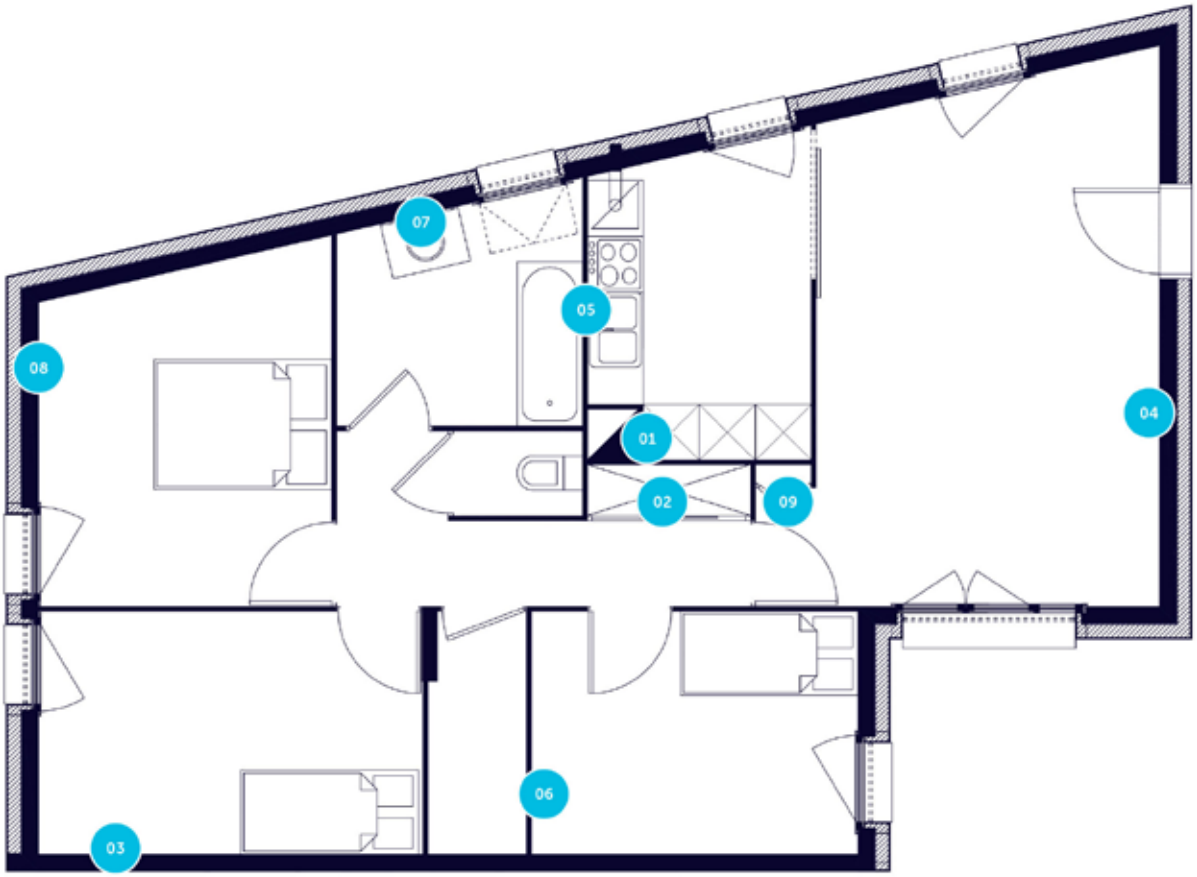
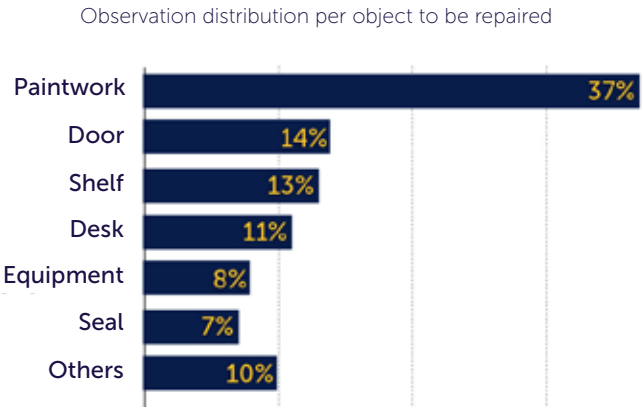


CARPENTRY



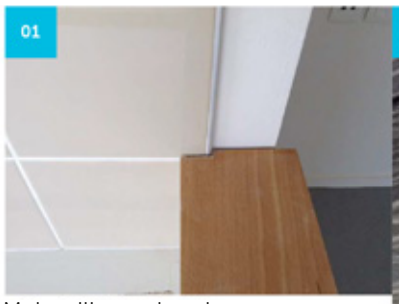
" Where are 1/3 of the defects? In a cupboard. "



Carpentry is mentioned as such in 5% of worksites. A targeted analysis on this type of activity helps to highlight defects relating to the installation of built-in fixtures. Most of the defects identified have to do with the installation of cupboards, and especially with installing shelving: installation not finished, shelves not mounted, screw cover not installed, silicone bead not applied, equipment not installed or shelf missing.

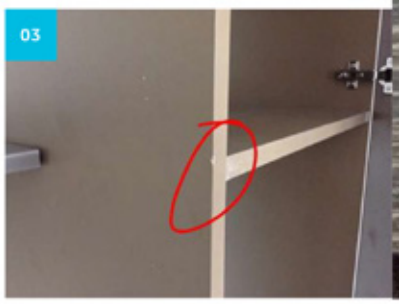
Yet the most notable defect remains the adjustment of doors and cupboards, accounting for 37% of the most frequent defects. Finally, it should be noted that cleaning is requested in 6% of the observations.

CARPENTRY



Make silicone bead

Install screw cover



Clean cupboard

Finish installing shelves

Attach shelf

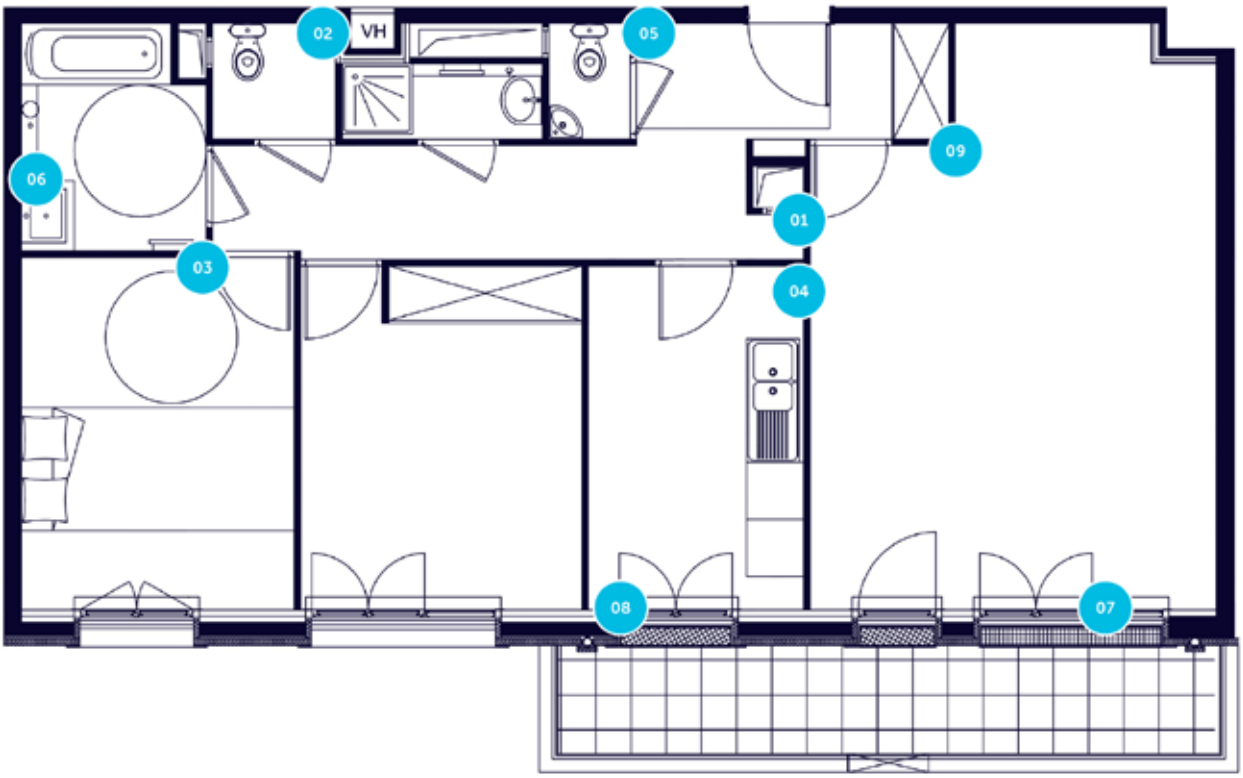
Install shelf

Install equipment

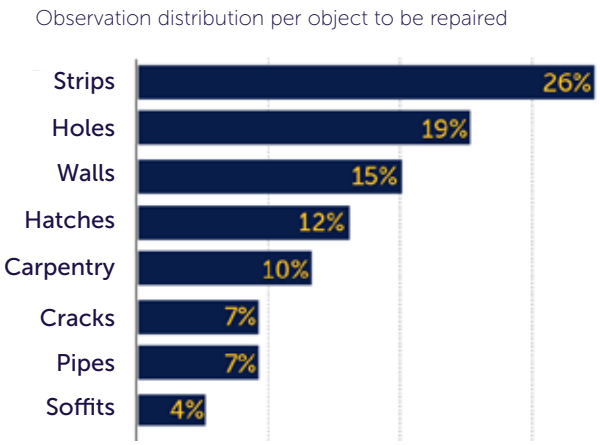
Install shelf

Adjust door

PARTITIONING



“ The plague of interfaces. ”



The partitioning category illustrates to what extent interfaces generate defects. Therefore, junction areas lead to cracks that need to be repainted, strips to install, holes to fill in or joints to redo.

Interfaces with plumbing are also significant with 19% of the most frequent observations. Redoing seals or even the whole wall around pipes and installing hatches to access the network are the most frequently identified defects. Finally, contact areas between walls and window or door frames remain problematic, with 25% of the observations gathered.

PARTITIONING

Fill hole

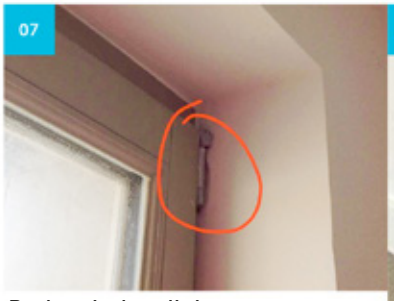
Seal pipe

Install acrylic joint

Install Soffite

Install hatch

Redo wall

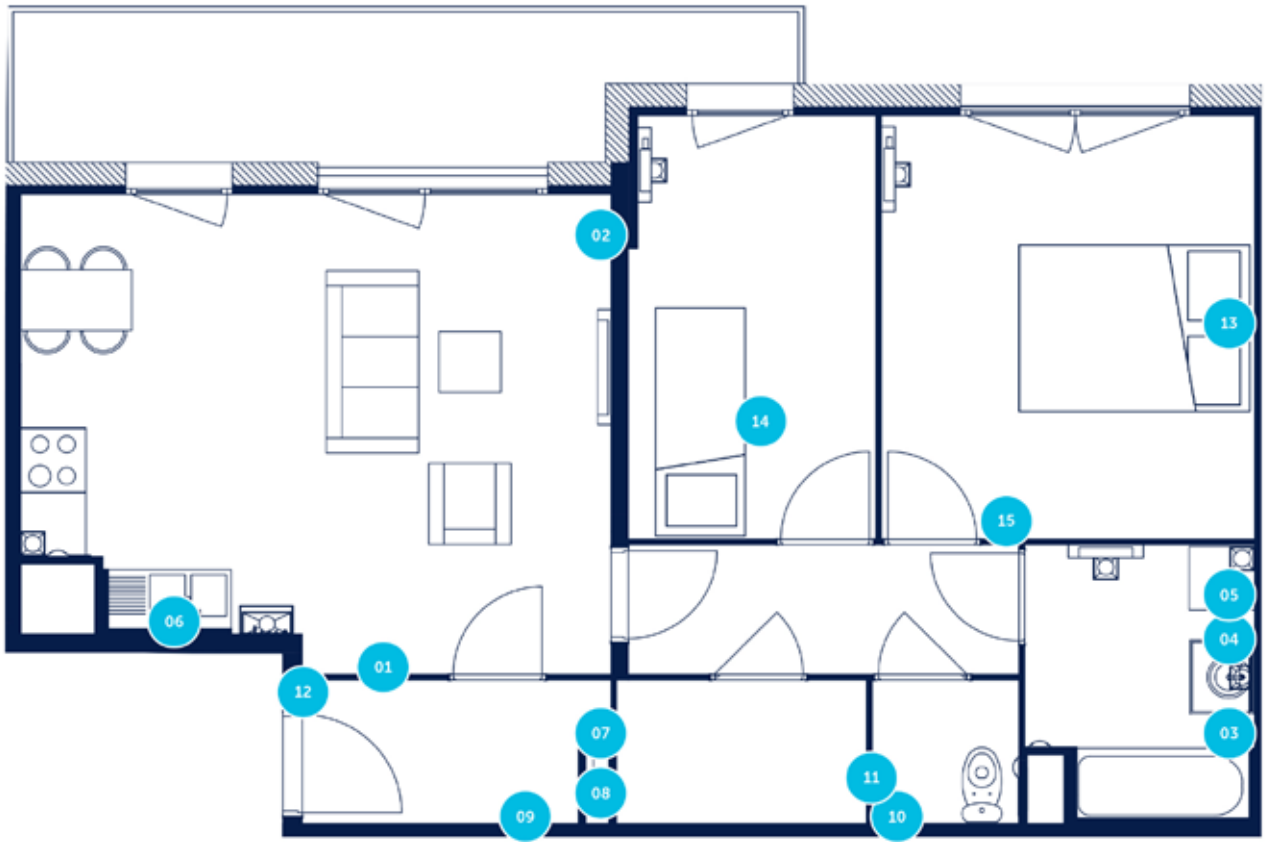


Redo window lining

Redo crack

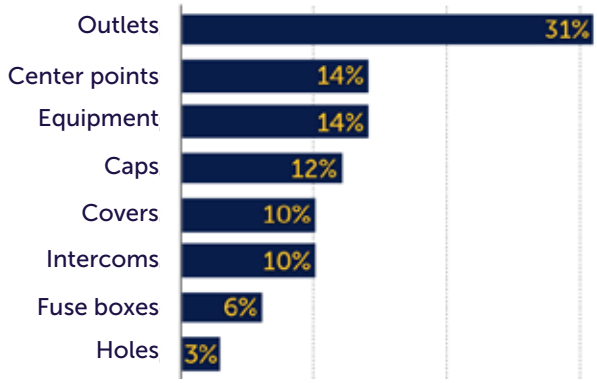
Redo strip

ELECTRICAL



" One of every three snags is a poorly aligned outlet. "

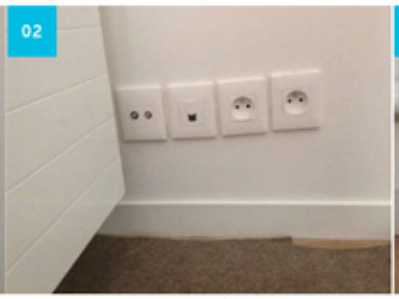
Observation distribution per object to be repaired



The analysis of defects associated with electrical works first reveal defects relating to the position and alignment of electric outlets (relating to about one third of recurring defects), center points, electric and lighting platforms. Furthermore, interface issues between electric equipment and walls entail unprotected electric wires, caps and covers not positioned and electric platforms poorly integrated into walls (absence of silicone bead, visible holes). Finally, some defects were revealed for electric fuse boxes, especially with missing labels.

ELECTRICAL

Attach outlet



Move and align outlets

Move outlet

Finish conduit

Move electric platform

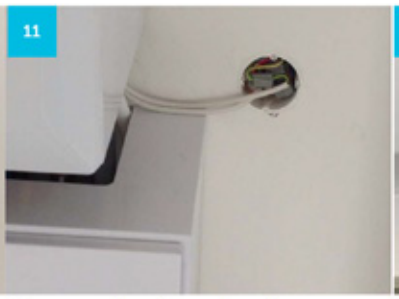
Remount lighting

Finish fuse box

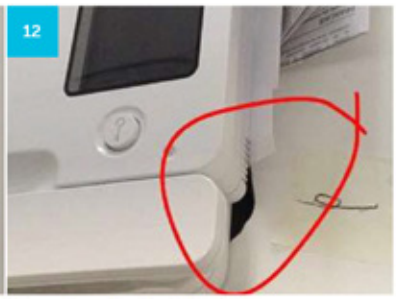
Finish labels

Do silicone bead

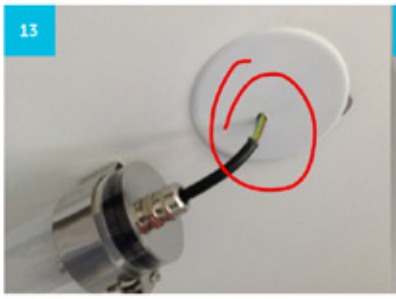
Install LNP tube



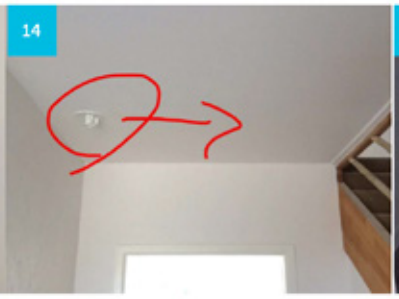
Install power cap on boiler



Fill in electric platform



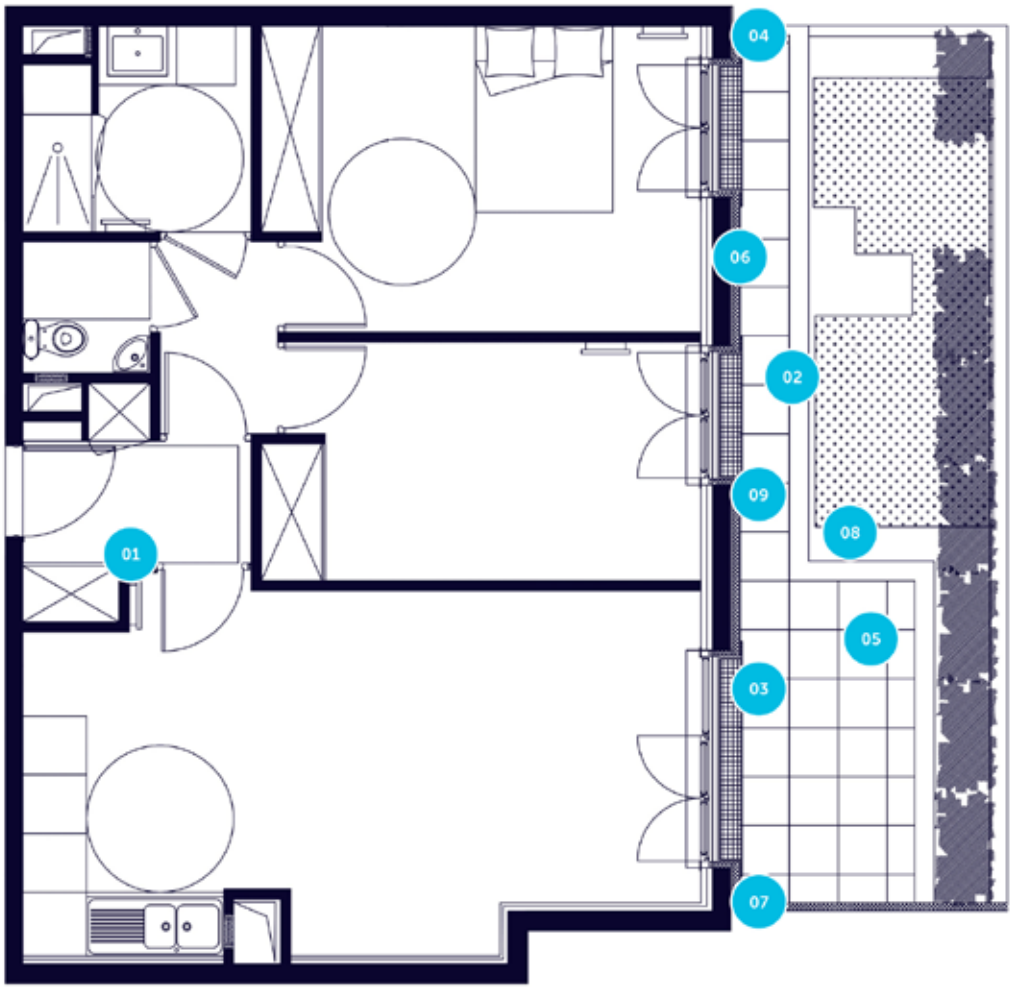
Redo lighting



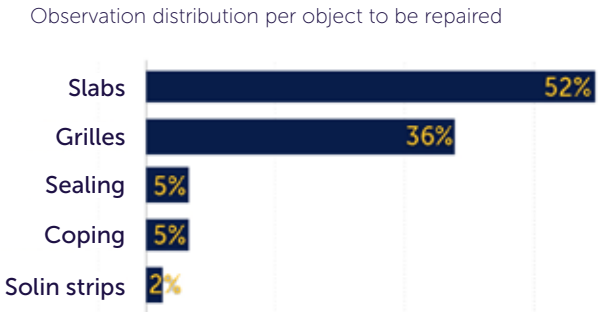
Re-center center point

Install cap

SEALING



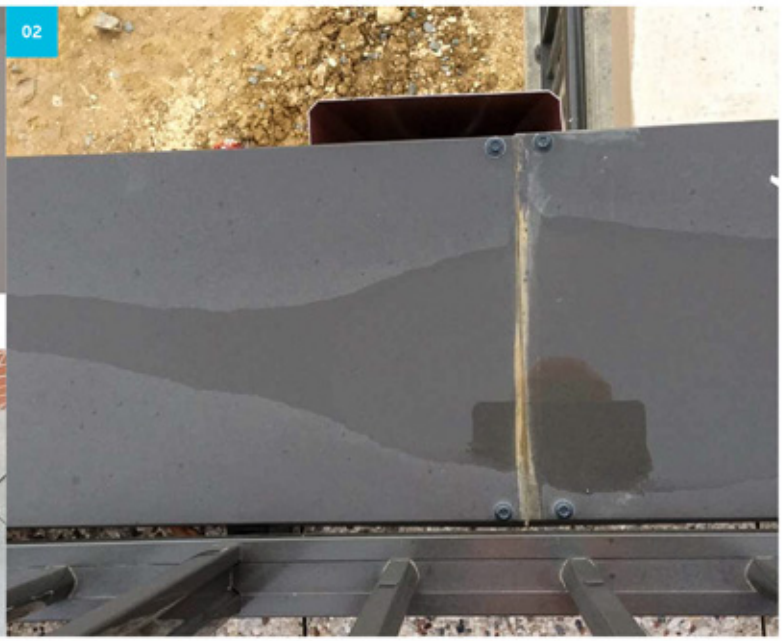
" A poorly installed slab in 50% of worksites observed. "



Observations made in the sealing category have mainly to do with defects in installing slabs, grilles and coping. Jobs to be redone were cleaning, alignment and the replacement of elements. We also noticed that in the delivery phase, very few observations had to do with leaks (1.8%).

SEALING

Leak



Clean raised slab

Redo coping

Install grille

Replace slab

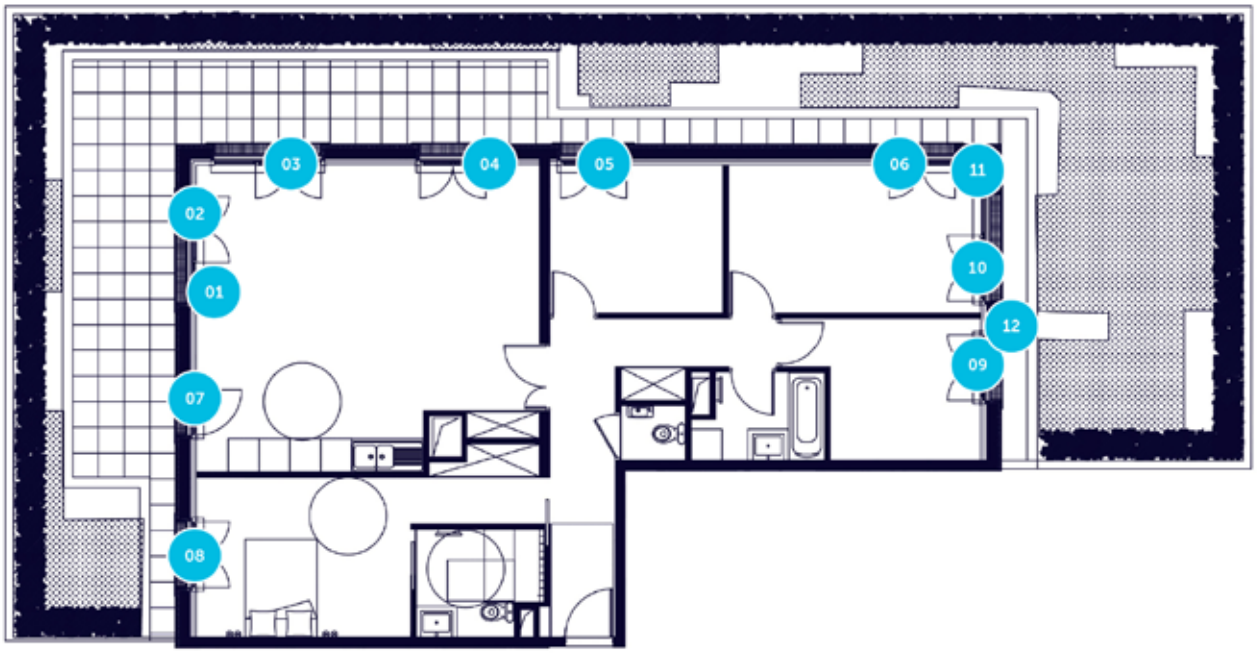
Redo grille

Redo slab around pipes

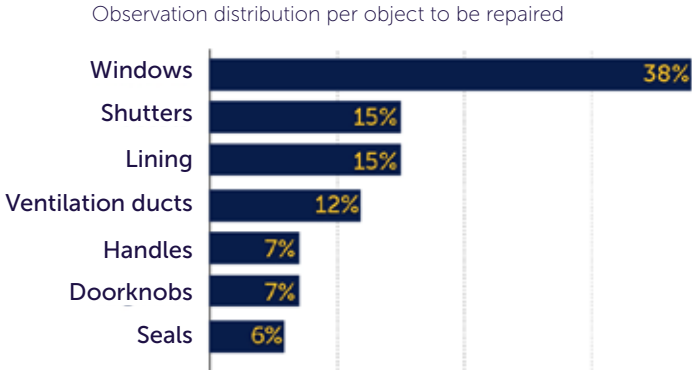
Redo raised slab

Redo resin

EXTERIOR JOINERY/GLAZING



" 38% of snags thrown out the window. "



The main observation from the analysis of the exterior joinery is the following: control work leans toward an inventory including observations split between accessories and missing joints. Attention is mainly given to doorstops, cranks and sealing on shutters. We also found defects in adjustments and finishing touches in windows (glass beads, windowsills and waterproofing seals) as well as ventilation ducts, which still make up 12% of recurring observations.

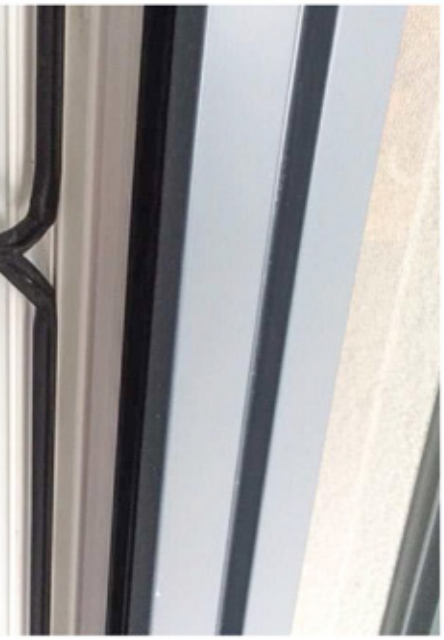
EXTERIOR JOINERY/GLAZING

Change silicone bead

Change windowpane

Change skylight

Install acrylic bead on the box



Finish glass bead

Change waterproofing seal

Install screw cover

Install ventilation

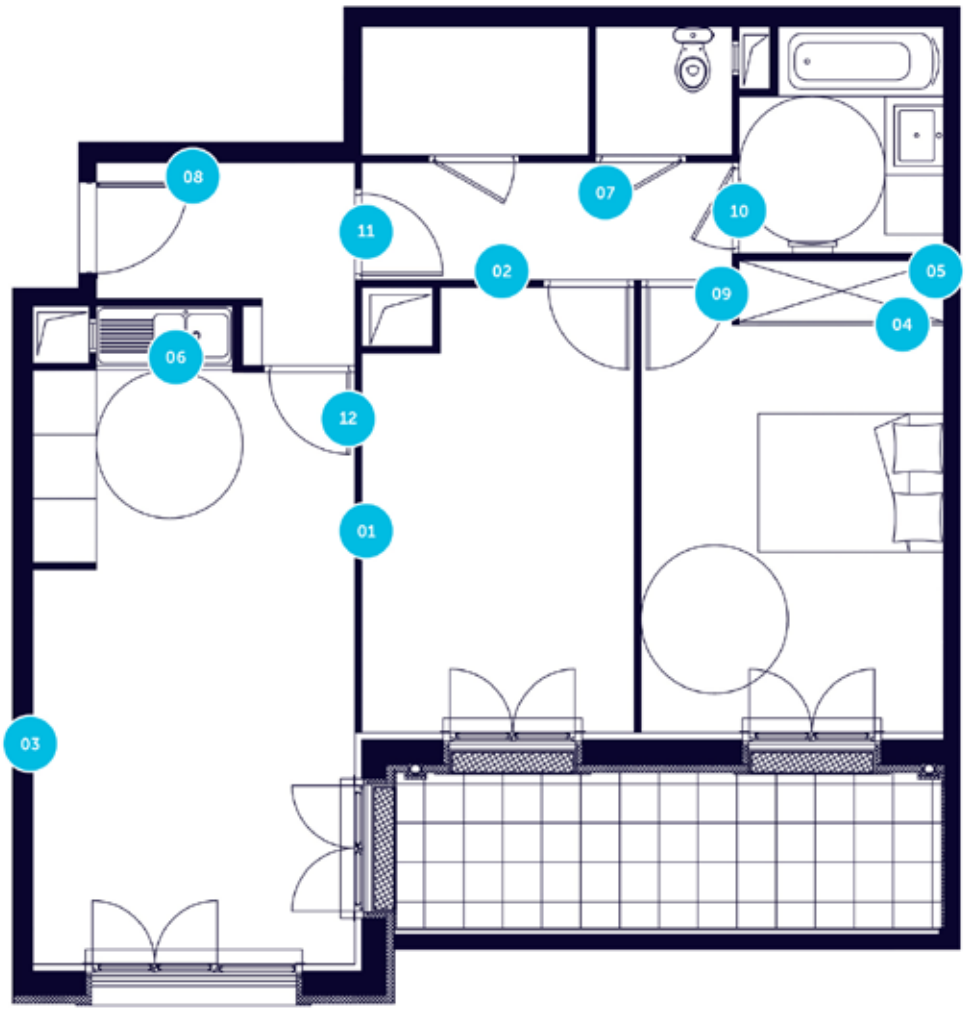
Install stop for rolling shutter

Redo frame installation

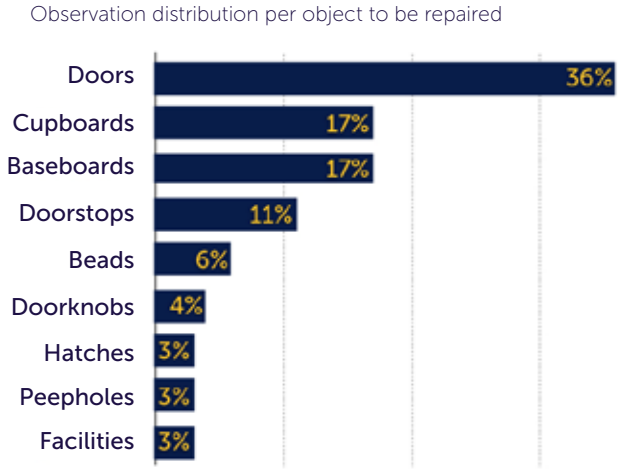
Install crank

Clean windowsill

INTERIOR JOINERY



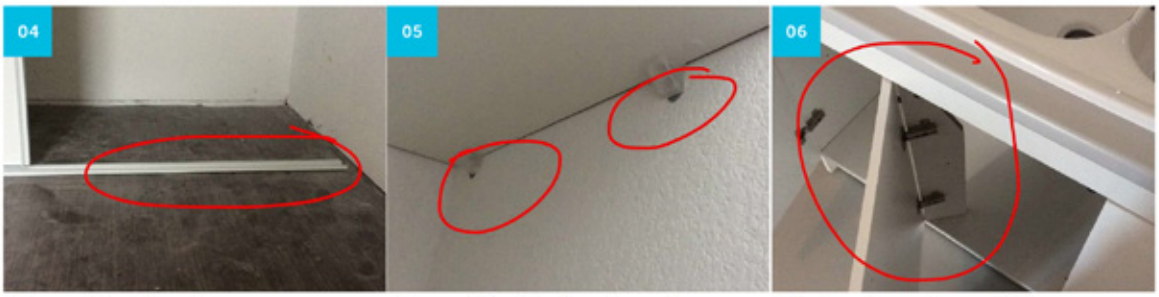
" One problem out of four at the doorstep. "



As a major source of snags, the particularity of indoor carpentry resides in the high redundancy of defects observed. Thus, baseboard installation is often neglected, ranging from cutting to the wrong size to slight visual imperfections. Punchlists on cupboards and shelves corroborates the analysis done on the layout category because mainly adjustments of windows and doors and equipment installation reappear. Finally, the adjustment of doors and associated hardware (locks, doorstops), resulting in 51% of the snags gathers, lead to most reworking orders.

INTERIOR JOINERY

Replace baseboard | Install baseboard | Redo baseboard

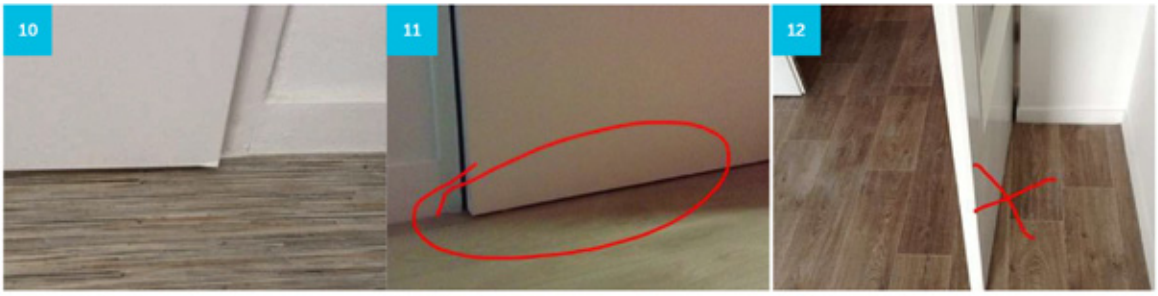


Redo cupboard | Redo cupboard shelf | Adjust cupboard underneath sink

Adjust hardware

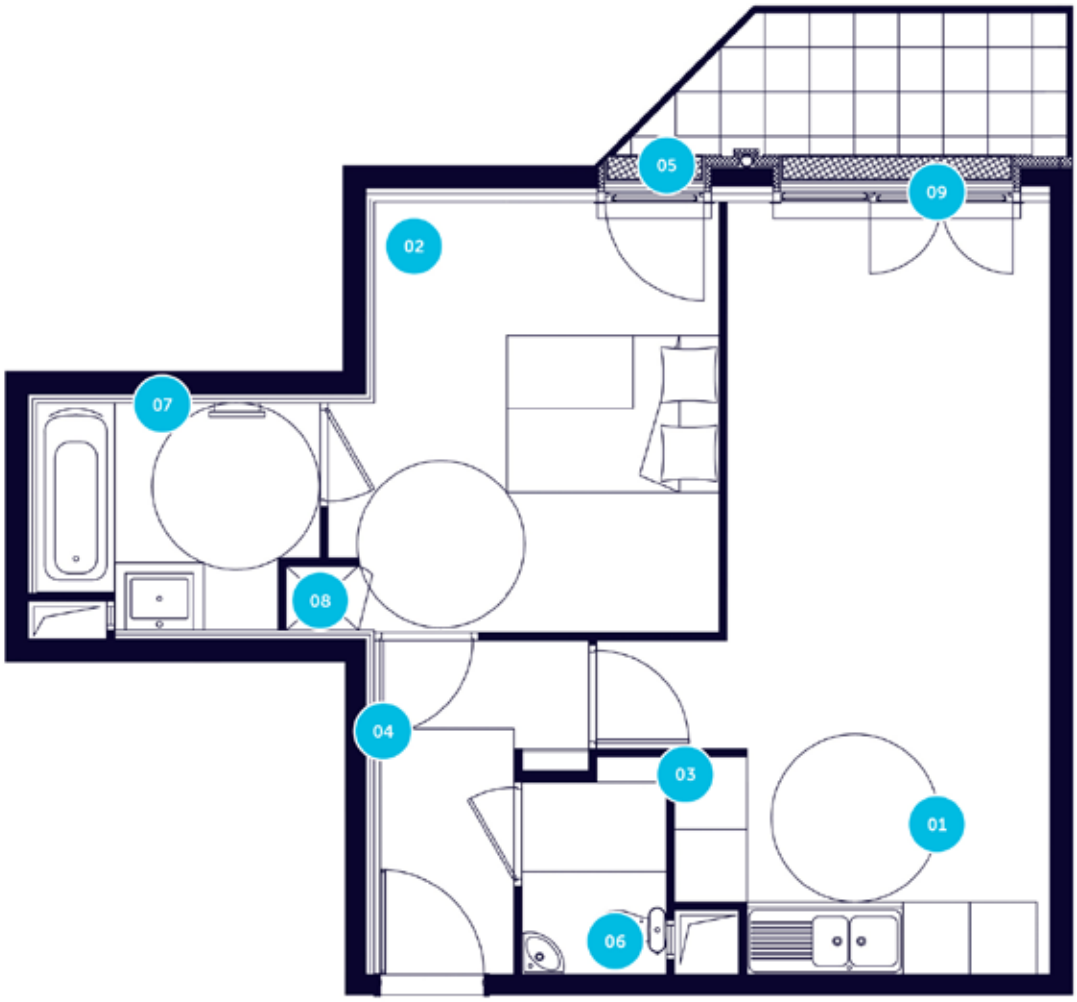
Replace doorstop

Recut baseboard

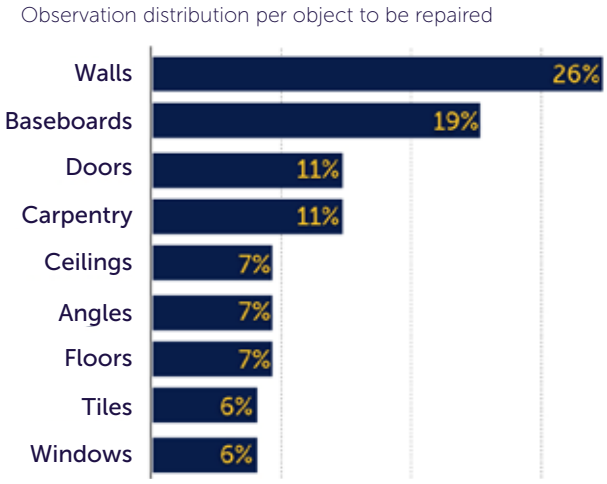


Adjust door | Plane door | Install doorstop

CLEANING



" Mr. Clean, where are you? "

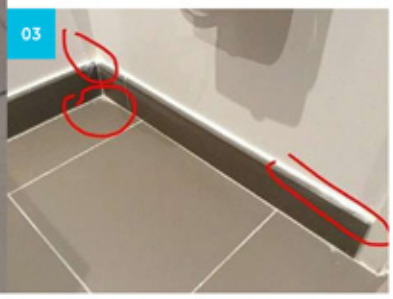


The analysis of observations associated with cleaning reveals the importance of the transversal nature of this category: snags result both from indoor and outdoor carpentry operations as well as the installation of floors and painting. The necessity appears for attention to details with regard to baseboards and above cupboards, for example, but the low dispersal of results prevents reaching specific attention points.

CLEANING

Clean tiling

Clean around rail



Redo runouts

Clean doorknob

Clean windowsill

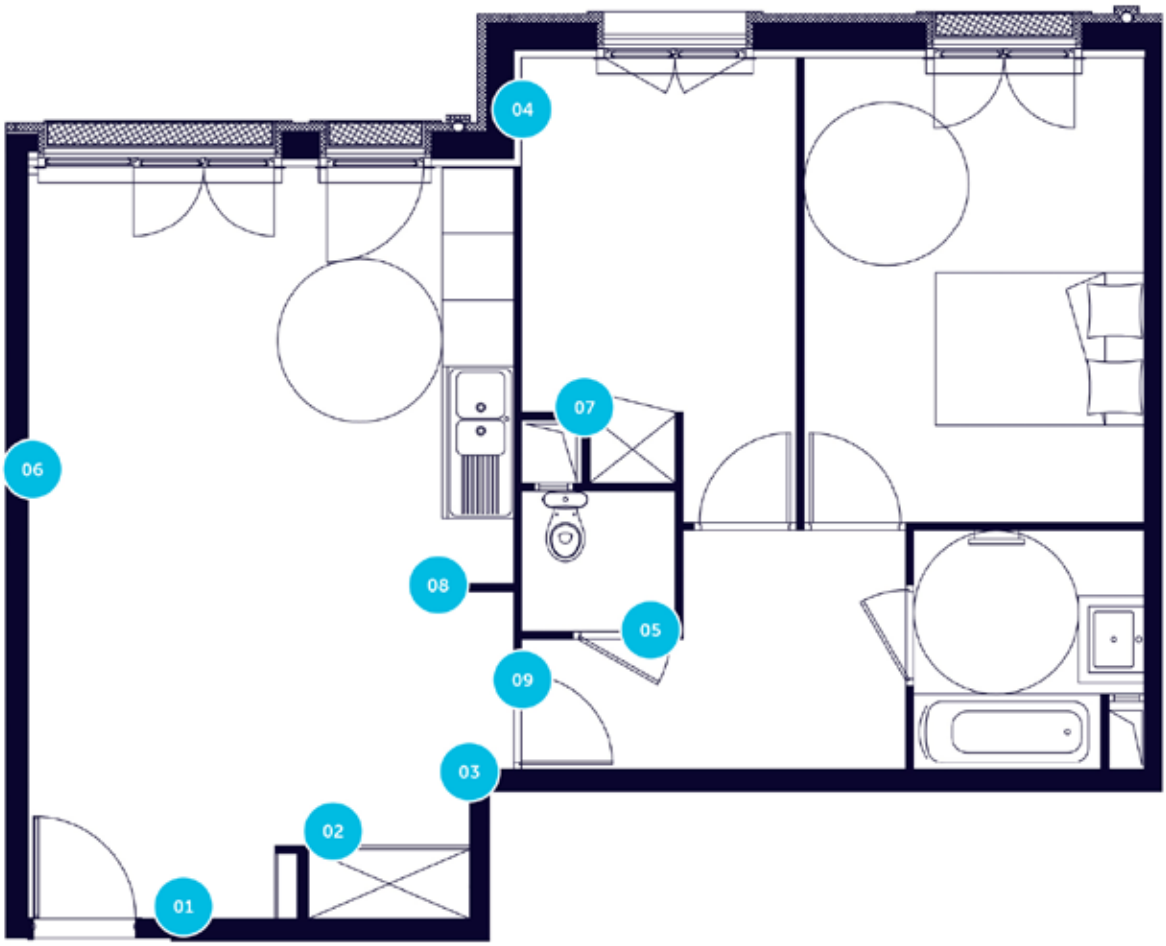
Clean toilet bowl

Clean ceramic tiles

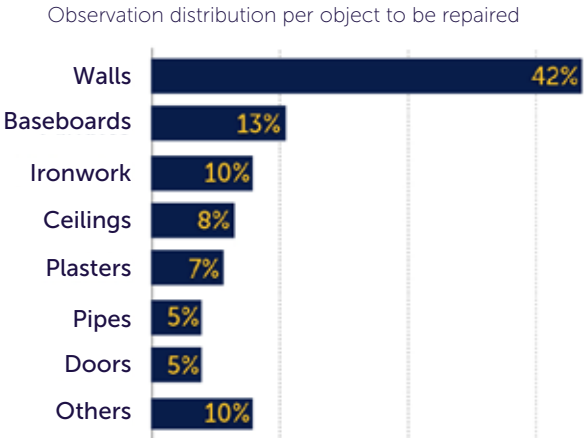
Clean top of box

Clean cupboard

PAINTWORK



" One out of three snags results from painting. "



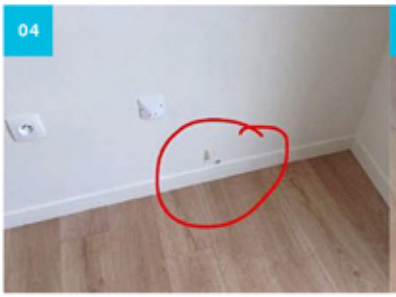
Paintwork is the category most affected upon delivery; one out of three snags results from painting. Generally speaking, the most recurring defects are located on walls and at baseboard-level. Defects at angles and near window and door frames are also very frequent.

PAINTWORK

Clean traces

Redo angle

Redo ceiling



Redo plaster

Redo window frame

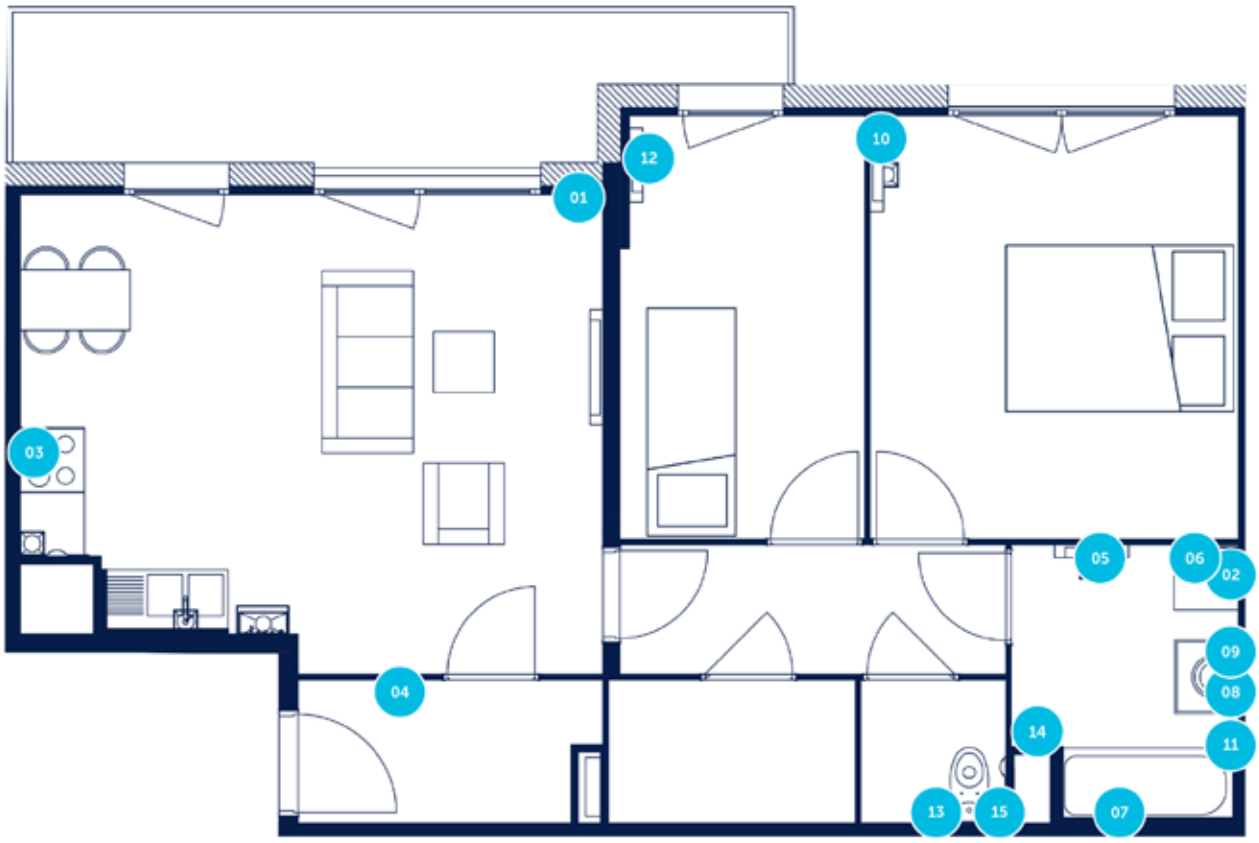
Redo wall

Redo baseboard angle

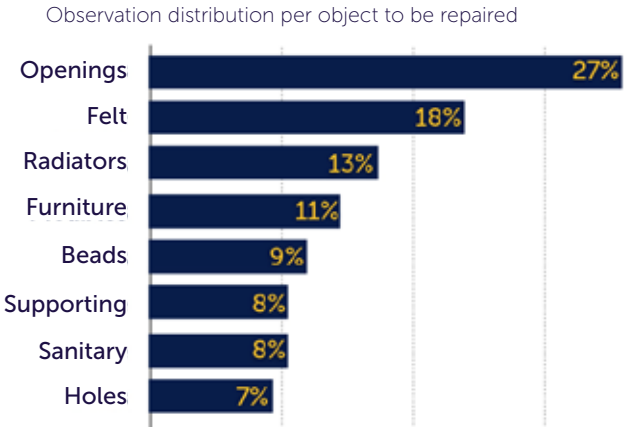
Redo wall

Redo baseboard

PLUMBING



" 10% of snags have to do with missing equipment. "

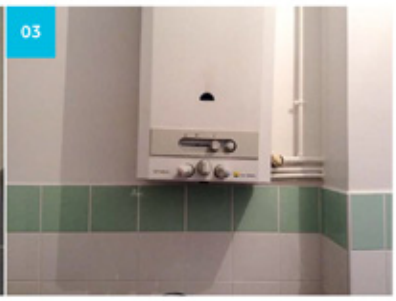


Finishing touches on plumbing have more to do with equipment inventory. Indeed, one out of three defects observed has to do with a missing part (drain, ventilation opening, thermostat, etc.). Then come problems with the placement of radiators and ventilation openings, dealt with by many categories of experts and which can be found in other categories such as locks/ironwork, for example.

PLUMBING

Revise radiator verticality

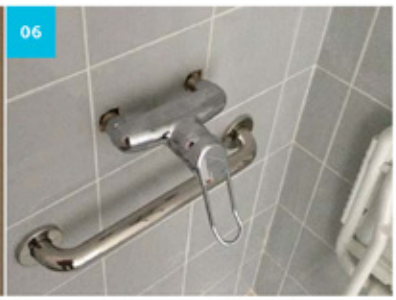
Redo opening



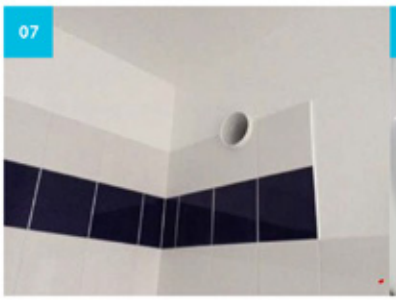
Reattach boiler

Install thermostat

Install bolt covers

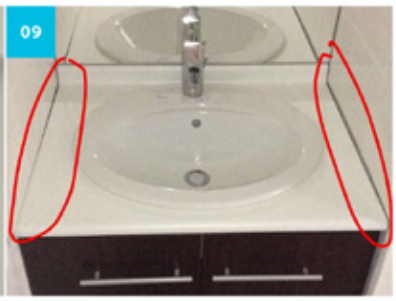


Install bolt covers on faucet



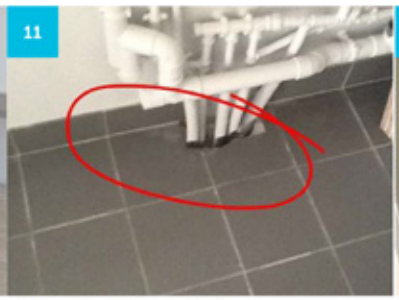
Install opening

Install drain



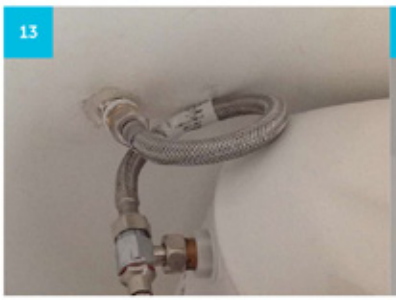
Finish up around basin

Finish up radiator power supply



Waterproof

Move radiator



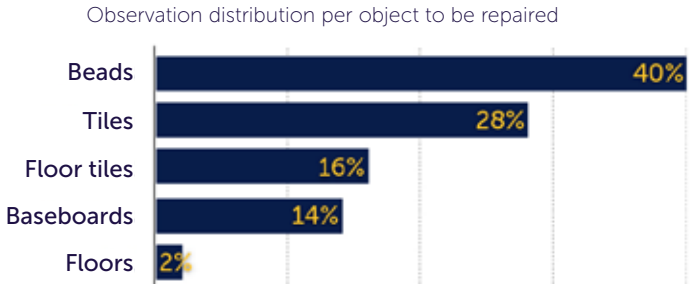
Replace hose

Replace opening model

Redo partition opening

HARD FLOORS & TILES

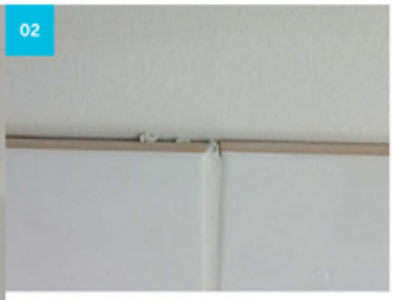
" The fault? 28% from tiles. "



In terms of items, defects mostly have to do with tiles, representing 28% of observations associated with this category. Generally speaking, grouting accounts for the most defects (40% of observations) especially in bathrooms near appliances (sink, bathtub, etc.). Finally, in one out of three sites, tiles need to be replaced at the delivery phase.

HARD FLOORS & TILES

Redo bathtub grout

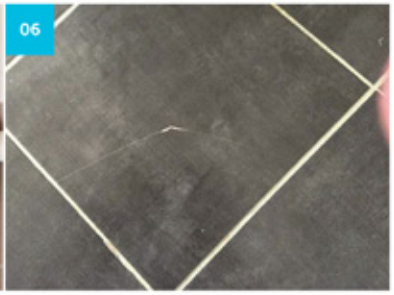


Redo acrylic bead

Change ceramic tile

Redo baseboard ceramic grout

Redo baseboard tile grout



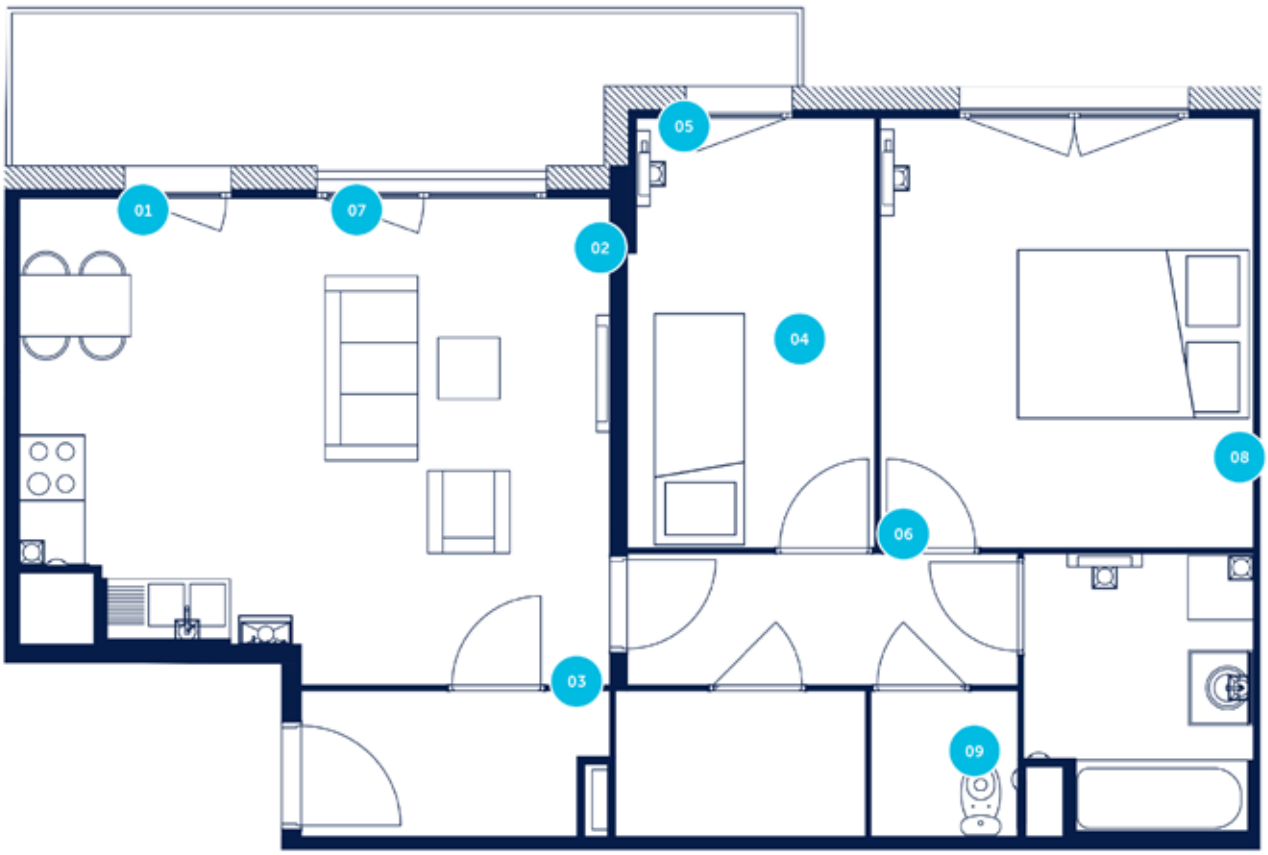
Change tile

Redo ceramic grout

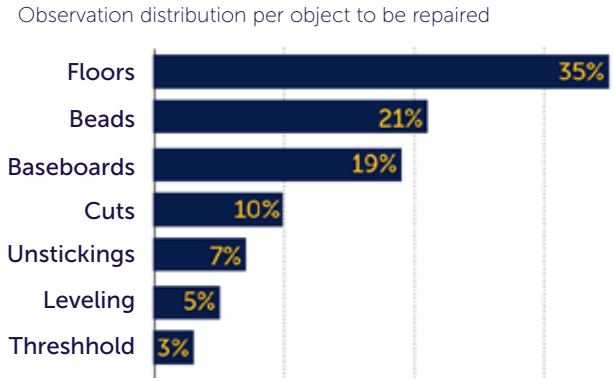
Redo baseboard bead

Redo baseboard

SOFT FLOORS



" In 21% of cases, the bead is defective. "



Soft flooring is abundantly used in bedrooms, high-traffic areas and common rooms in public housing. The analysis of this category reveals that a large majority of defects have to do with redoing silicone beads (20% of the time), but the most recurring defects are concentrated in floors that interface with baseboards and doorframes.

SOFT FLOORS

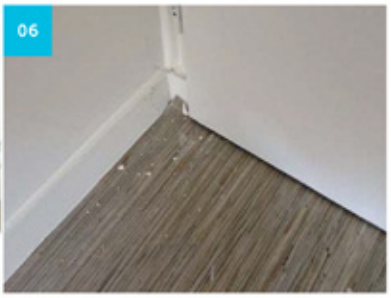
Redo door threshold bead

Redo silicone bead

Redo bead with baseboard

Redo floor

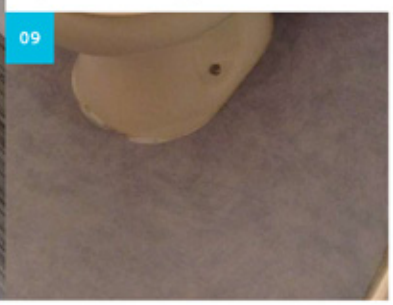
Redo unsticking



Recut

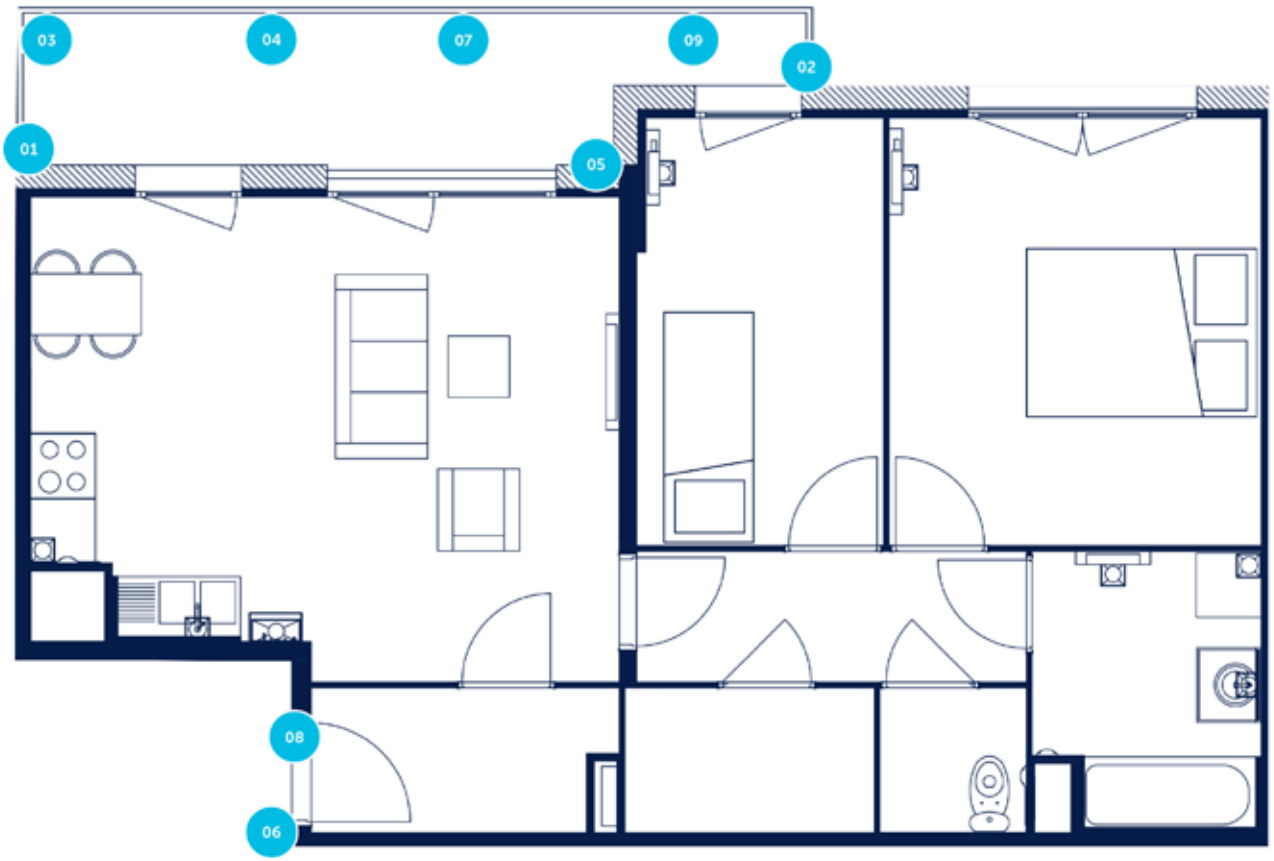
Re-install

Redo padding

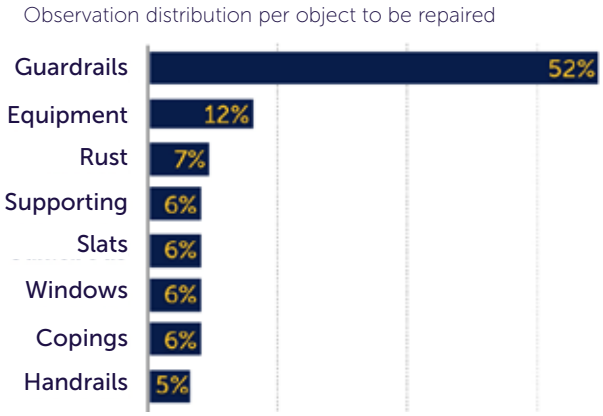


Redo bead around appliances

IRONMONGERY & METALWORK



" How can you guard a guardrail? "



Recurring defects associated with this category are more than 50% concentrated around guardrails, from structural importance (attachments to be redone) to aesthetic importance (rust stains, missing screw caps). More generally, we observed a notable presence of defects in equipment installations such as coping and grilles, which can be found in the "Sealing" category.

IRONMONGERY & METALWORK

Put cap over bolt

Add guardrails

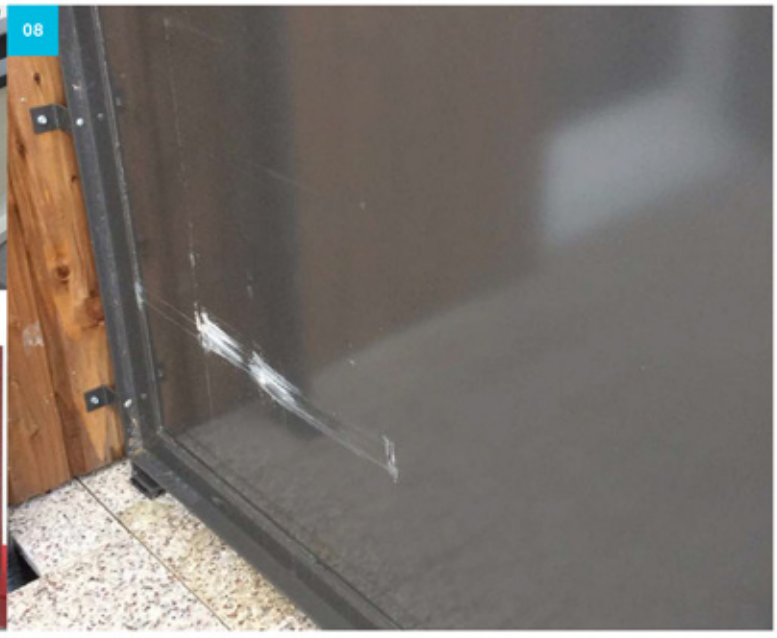
Redo guardrail

Attach guardrail

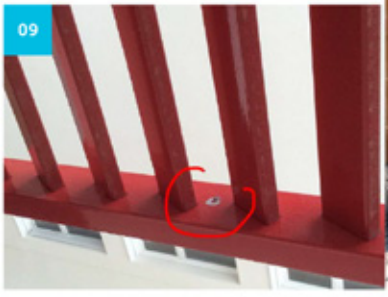
Put on screw cap

Put on caps

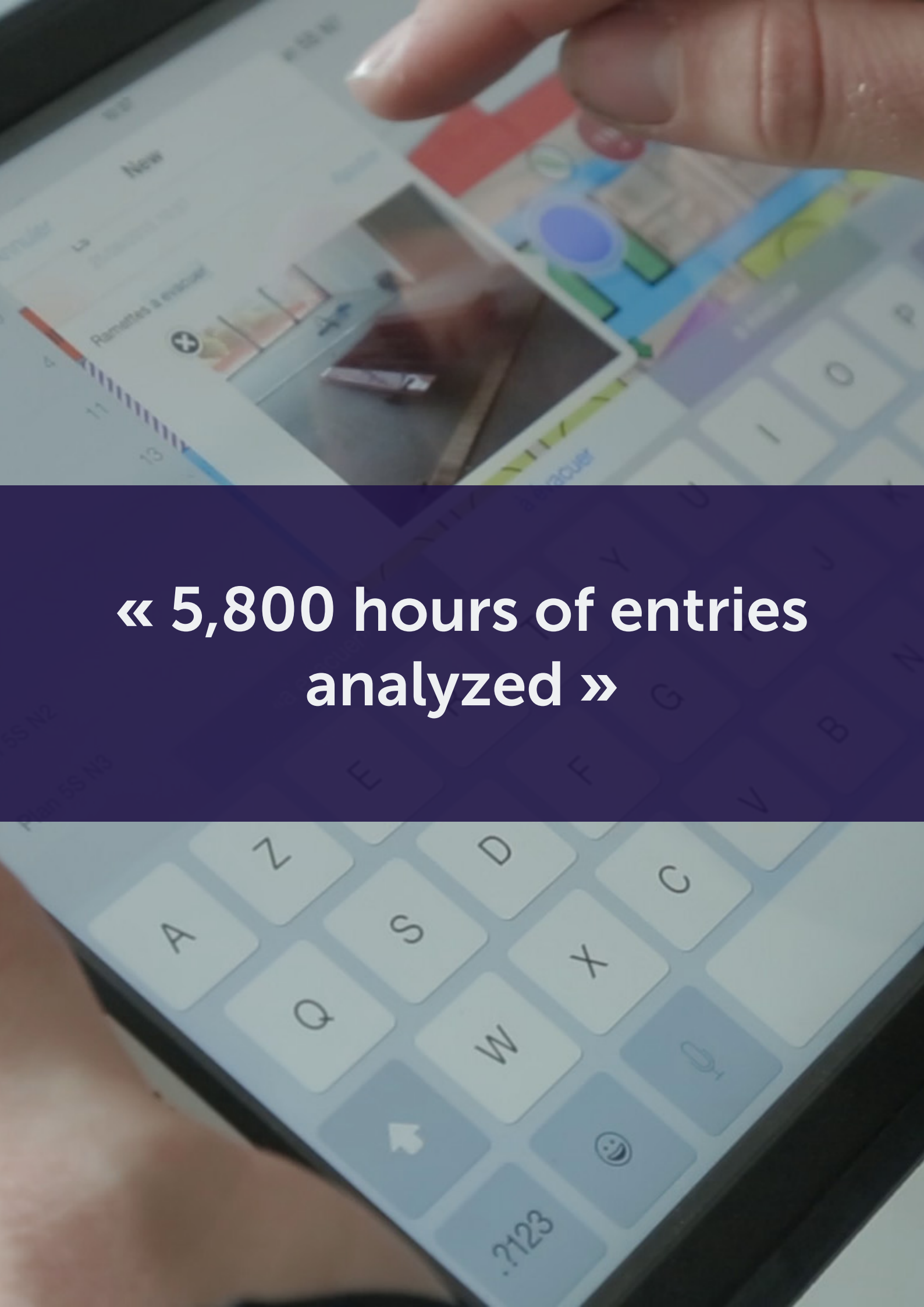
Clean guardrail



Change privacy protection



Redo guardrail



« 5,800 hours of entries analyzed »

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METHODOLOGY

METHODOLOGY

This study was carried out in two phases: collecting information constantly for more than 3 years (about 5,800 hours of entries) followed by a data processing phase.

Collecting information

1. A simple, intuitive application used by workers

All observations were collected directly on the field thanks to the FINALCAD application, which was developed especially to allow operational workers to digitize their note-taking as quickly and as naturally as possible. Therefore, with only 3 movements on a touchscreen tablet, an architect can locate a defect on a blueprint, assign it to a category and/or company, qualify the defect (e.g. "Install doorstop") and complete this description with a photo and a comment.

2. An analysis of the data prepared by standard and collaborative configuration of the tool

Although an ergonomic mobile app is the starting point for collection, the fact still remains that putting a digital solution into service to gather information about a construction site is exposed to the following risks:

- Statistical processing of the information is impossible if the information entered is not structured;
- Giving up using the tool following configuration operations that are too difficult;
- Processing the information may be affected by improperly using the application. It could be imaged that the same defect is created twice on different blueprints (edge effect);
- Use may be slowed by the transparency involved in digitizing information.

METHODOLOGY

To protect against these risks, all of the collection operations were performed in the context of a service offered by FINALCAD built around:

• Common structuring: every observation is necessarily related to a category, a company, a description and a location;

• Standardized configuration: library of typical observations and areas (residence, traffic, staircase, etc.);

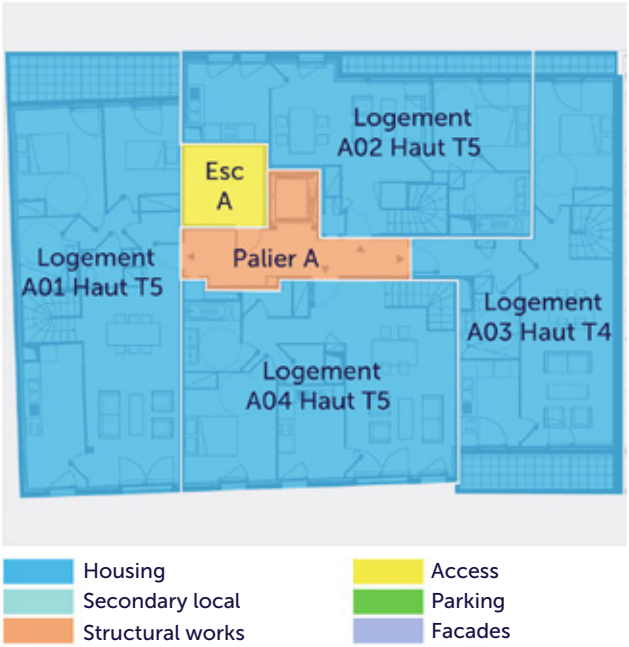
• Configuration modifiable by the user (adding typical observations, for example) so as not to stop use;

• Networking and organization of project blueprints performed by the FINALCAD production team.

This work guarantees simple and quick navigation and limits the risks of entering the same observation on two different blueprints:

• Configuration integrating the notion of the role of the user to limit the visibility of the information entered only to interested parties. For example, a subcontractor will not have access to the list of defects assigned to a different company.

Types of locals, objects...



Category types

Appellation	Lot tag
16 Elevator	Elevator
Lot 9 - Plastering	Plastering
Lot 11 - Electricity	Electricity
Lot 4 - Sealing	Sealing
Lot 3 structural works lots	Structural works
Lot 7 - Outdoor carpentry	Outdoor carpentry
8.1 - Indoor carpentry	Indoor carpentry
Lot 6 - Lock	Ironmongery & Metalwork
Lot 15 - Painting	Painting
Lot 10 - Plumbing	Plumbing
Lot 13 - Hard floors	Hard floors & Tiles
Lot 14 - Soft floors	Soft floors

3. Taking action about information reliability

The relevance of the source of the data used in this report is all in the fact that the information collected was entered directly at the worksite using a mobile app. It was prohibited to leave users with the possibility of entering information through a web platform because this type of tool authorized entering "off" the worksite.

Finally, we emphasize that the collection process was done constantly by the very stakeholders of the worksite. This study is not the same as one-off audits done by external services and as a result, has a very different scope.

Post-processing

The objective of this analysis was to identify the most recurring observations for a given category (exterior joinery, plumbing, electricity, etc.).

However, even though the configuration of the application was standardized, a margin of freedom was systematically given to users to as not to hinder learning how to use the tool. Users could define a defect themselves without having to select from typical observations. Similarly, the configuration of the categories (list and lexicon) was left up to choice of users, who sometimes wanted to integrate a code or nomenclature system when identifying categories: "04 Paintwork" or "A03 – Paintwork."

This flexibility, which is essential for quick appropriation, resulted in a dispersion of the lexicon used when defining observations. To describe a configuration action, the following verbs were used: set, wedge, adjust, reorient, balance, lift, lower, lean, etc.

Thus, to do this study, a labeling phase was required in order to categorize each of the one-million observations per category. These labeling operations were performed in successive iterations by using automatic categorization algorithms, updates to glossaries and analysis phases to validate the coherence of the "labels" selected by users for an observation.

This labeling work was done especially to describe the observations created, a qualification constructed around an "action/item" pairing (clean stain, adjust door, fill in hole, etc.). It was observed that users did not systematically follow this convention (the action or item was sometimes missing). Since the goal of the analysis was to identify the most recurring observations for a given category presented with a complete "action/item" pairing, for incomplete pairs, it was necessary to enhance the analysis work with a study of comments and photos used to describe the observation.

Information processing operations therefore relied, first of all, on automatized algorithmic intelligence, and secondly, on human analyses focused on the business coherence of the results obtained.

« 24 million euros spent every year on redoing seals »

FINALCAD
CONSTRUCTION OBSERVATORY

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CONCLUSION AND OUTLOOK

CONCLUSION

The statistical examination of observations issued category by category in several hundreds of worksites all over France raised three questions:

What can be done to define and efficiently share standards of quality of delivery?

This study brought up a surprising observation: at all worksites, the snags mentioned are almost always the same. This low dispersion of snags identified is even more flagrant when examining the photos taken by workers to illustrate the observations. Once again, they are almost all identical.

This overall analysis emphasized that a standard of quality of delivery for a construction is very likely dormant. For a given category of workers, this standard may seem obvious at first glance, like an electrician placing a cover around an electric outlet. However, it is surely this silence surrounding obvious facts that gives rise to the "butterfly effect": slight defects with disastrous consequences in the long term.

It is therefore urgent to establish a common base, to explain this implicit quality standard and to share it. This study shows that initial recommendation can be formulated simply by automatically feeding the knowledge base expressed during the delivery phases.

Is the organization of interfaces truly effective?

Furthermore, this analysis highlighted a significant number of defects located at interfaces of secondary work categories: missing seals between a fuse box and a wall, baseboard to be redone after moving a pipe, electric outlet to be moved following a change in a partition, doorstop to be moved after installing a baseboard, etc.

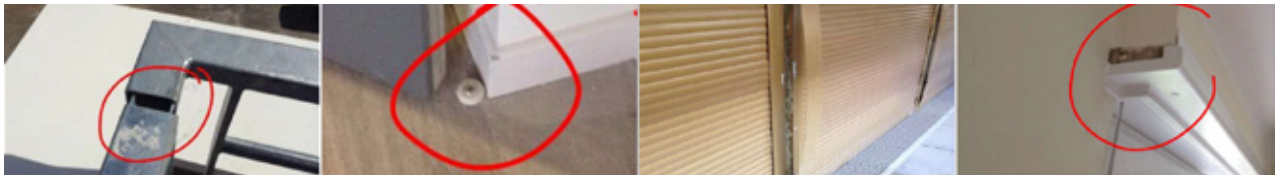
All these defects highlight to what extent an organization of work where specialized workers file through one after the other will inevitably lead to defects in case of late modifications. These defects are often a source of contention when signing off a work category is not framed with delivery procedures.

Faced with these phasing problems, rather than spending energy calling up on one company rather than another to do reworking, the idea seems evident to call on multitasking companies that are able to quickly convert a resident from non-compliant to compliant with a standard of quality for delivering construction work.

Documenting a "who does what?" file based on the most recurring defects illustrated is another possibility to be considered to harmonize the contractual relationships between the various work categories and their coordinators.

CONCLUSION

Do workers give up on the quality of finished work under the pressure of unrealistic deadlines and insufficient budgets ?



Finally, this study could not be concluded without bitterly remarking that many observations seem to highlight a lack of professionalism in some companies: missing shelves, unaligned outlets, outlet covers not installed, non-adjusted cupboard doors, unreachable fuse boxes, soft flooring or tiling installed with leveling defects. Similarly, isn't it a pity to see that remarks having to do with cleaning are multiplied, as if being concerned with completing work within normal standards is beyond some people?

Indeed, this last observation should be weighed against tight budgets forcing companies to hire unqualified and little-supervised laborers on the one hand, and on the other hand, by tighter and tighter schedule that leave time for neither the time nor the flexibility of using control phases and intermediary delivery between work categories.

OUTLOOK

Since its creation in 2011, FINALCAD has set as a mission for itself: increase quality, reduce its cost and make it accessible to everyone. With the launch of the FINALCAD Construction Observatory and its first study devoted to public housing, this mission has never been more relevant than it is today. This accomplishment proves that beyond the productivity support provided by digital tools, above all, it is the collective intelligence and the data collected that make up the true added value of digital tools.

However, there is substantial room for development to make the smart exploitation of this data even more inclusive, accurate and relevant to the benefit of all stakeholders in the industry. To go even further, we have identified especially four particular development focus points: the accessibility of digital tools, interoperability, BIM, and finally, the benefits of predictive analysis.

Accessibility of digital tools

Today, there is still a digital gap between architectural and engineering offices on the one hand, which are often very well equipped for the virtual project design, and on-site workers on the other hand, who have little to no access to digital tools.

However, this "multitude" of on-site workers is indeed crucial so that the collection of observations is significant and for collective intelligence to come to fruition. The larger the samples of observations collected, the higher the factors of confident in the data. Making digital tools accessible to all workers without exception entails the provision of free or very low-cost tools and for their use to be as intuitive as possible to limit the time and cost of training. These worksites are part of the objectives set by the Digital Transition Plan for Construction.

Interoperability

Quality is an issue of planning, job by job. A byproduct in expanding the collection of observations to all work categories is the interoperability of the tools used by each worker.

Indeed, every type of worker prefers using specialized tools and it is unlikely that a single platform can meet all needs. However, exchange standards may be implemented between the tools, such as IFC data models, an exchange format dedicated to construction, promoted in France by the Mediaconstruct Association.

Building Information Modeling (BIM)

Although expanding the base and scope of collecting observations may make the data more reliable and exhaustive, it is also possible to make it more accurate.

Building Information Modeling, or BIM, helps to gather more accurate information beforehand about the elements to be observed on site (their location, the materials used or their interdependence with other elements).

Given this, BIM may contain a lot of information and may seem complicated for workers who are not yet familiar with this technology. It is therefore important to remember only the information useful in a given context, without which the accessibility mentioned above may be affected. Once again, the Digital Transition Plan for Construction has identified the necessity to break BIM into "BIM Kits" to facilitate its adoption by as many people as possible.

OUTLOOK

Predictive analysis

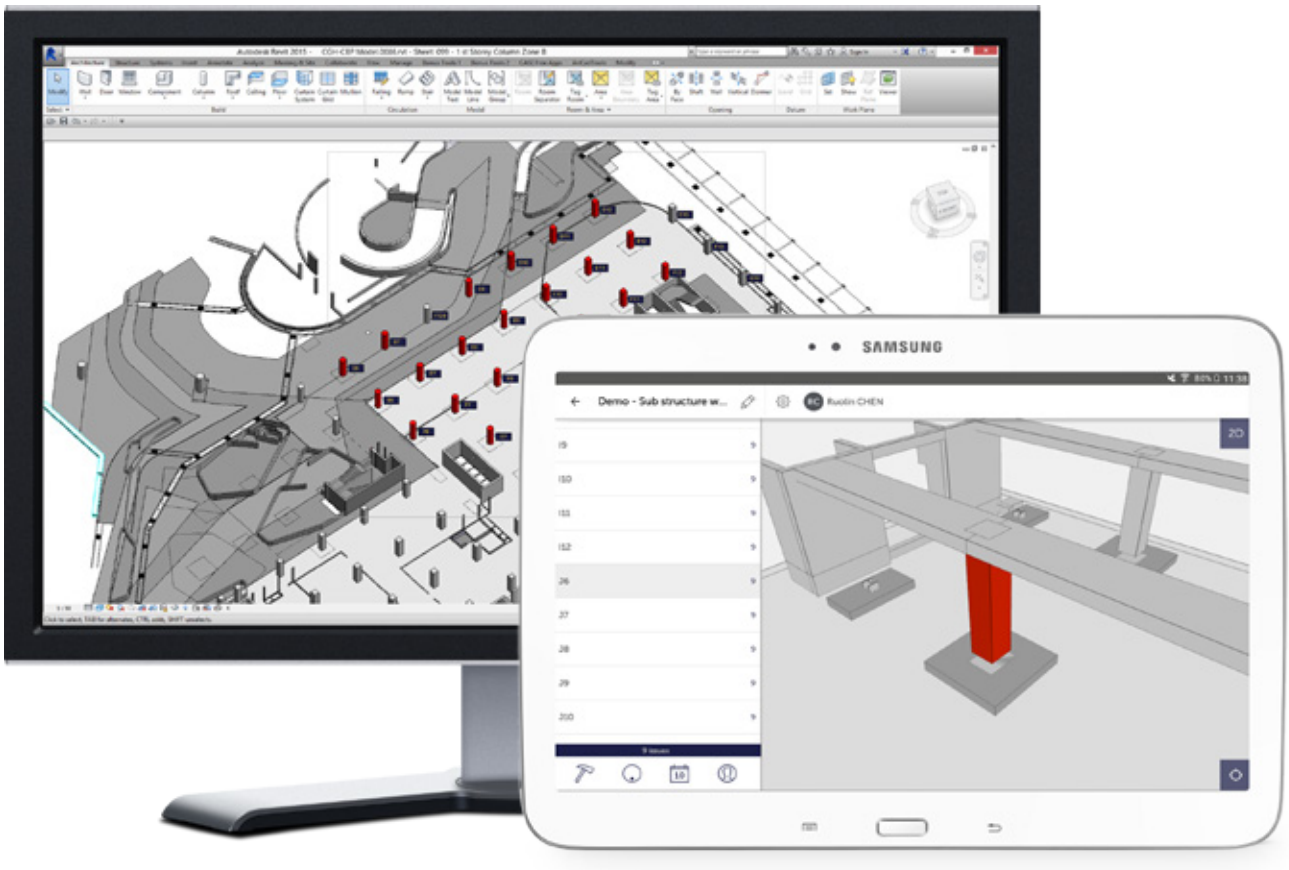
With more reliable, more exhaustive and more accurate data, the benefits of predictive analysis become possible.

With a sufficient sampling base, a typical project could emerge, such as the typical social residence described in this study.

We might be able to anticipate which quality defects are most frequent in a given project down to a single factor of confidence. Such a list may then be integrated into the control plans to systematize and rank controls on the most probable defects.

Beyond this, defects in work in progress can be quickly identified if they follow a sequence of typical events, and alerts will then be triggers to deal with quality defects as soon as they appear, if they have not already been anticipated.

This is where the entire challenge lies: reducing the size of punchlists before delivery by anticipating problems at the source or by immediate corrective actions, if applicable. "Building well on the first try" cannot only be done using purely virtual models (digital blueprints), this inevitably takes place through actual observations representative of what takes place on site. This snapshot of reality implies a collective effort. The technology exists and is ready to reveal its full potential as soon as there is a joint desire set into motion to improve quality.



BIM integration for usage on the field.

ACKNOWLEDGEMENTS

The FINALCAD team thanks all of the partners and economic stakeholders who, through their everyday work, helped to gather all the data and to create this status report in order to do an analysis for the benefit of all involved. Even though we cannot name them here, we know they are very much driven by their desire to produce within the best times and quality.

We would like to thank Philippe Estingoy, general manager of the Construction Quality Agency, for the editorial to this initial study, for his advice and his confidence.

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Data of this study come from the FINALCAD™ Construction Observatory analysing 30 000 housings from 2012 to 2015.

CONSTRUCTION OBSERVATORY

FINALCAD

PARIS - LONDON - SINGAPORE - www.finalcad.com
contact@finalcad.com - +33 1 69 81 97 08