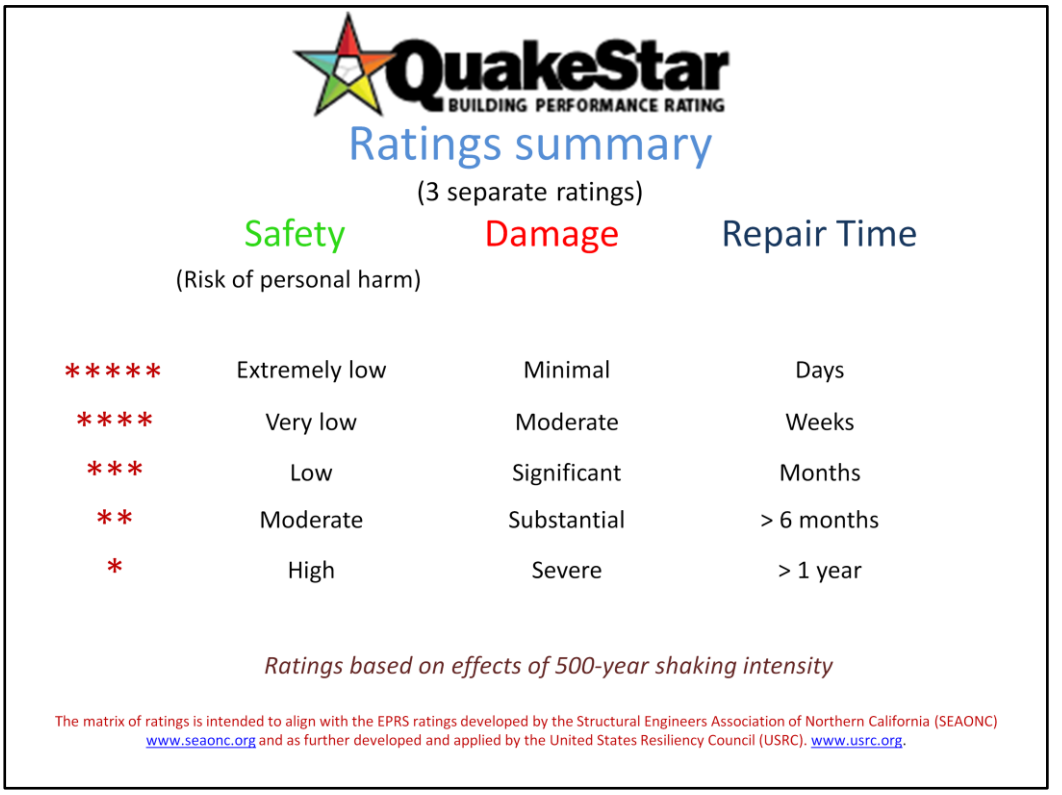
A rating system for New Zealand buildings

QuakeStar is an incorporated society formed to establish and operate an earthquake rating scheme for New Zealand buildings, including houses.

The aim is to improve the management of earthquake risk in the property industry by providing owners, tenants, users and the public a basic means to distinguish between buildings on the basis of assessed earthquake performance in terms of safety, damage and repair time.

QuakeStar is a private sector initiative funded by stakeholders in the property industry, building users and the general public.



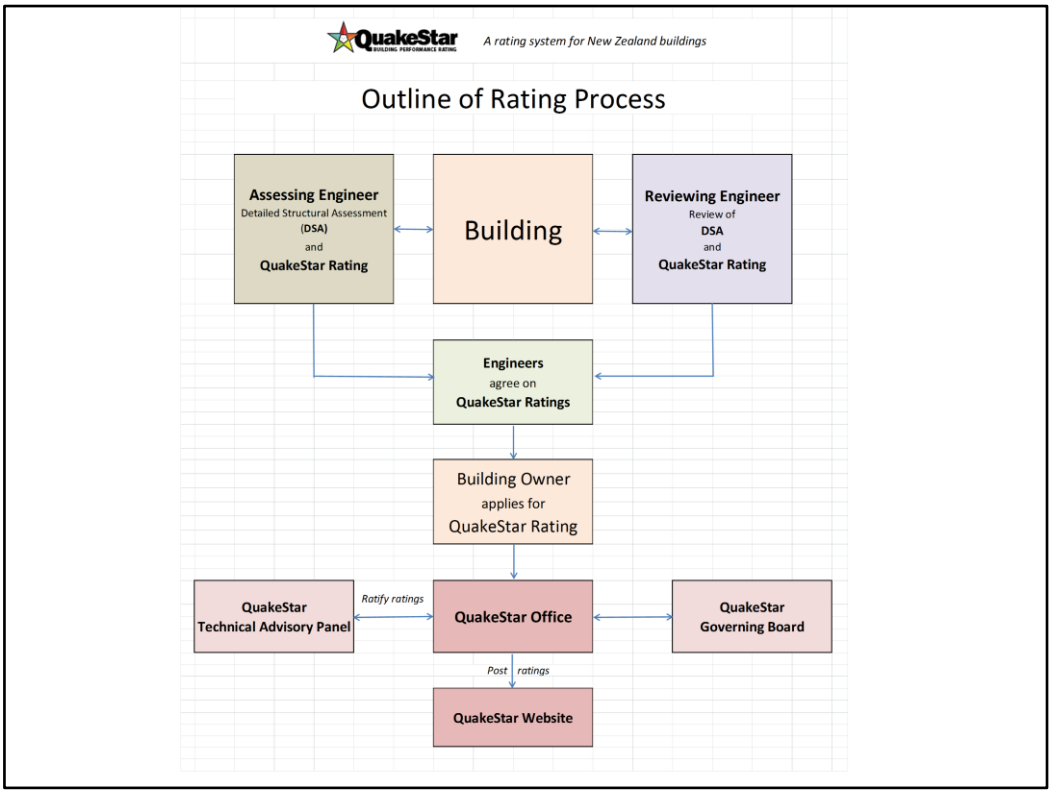
The ratings are based on assessment of the performance of the building in earthquake shaking matching that used in the design of new office buildings.

- Safety Rating reflects overall performance of the structure and building elements and their strength and integrity from a safety perspective.
- Damage Rating indicates damage that could occur in that level of shaking.
- Repair Time Rating indicates the time required to repair the building – assuming access to it and availability of reasonable resources. It does not account for lack of access to the building beyond the control of the owner.

Taken together, these ratings give a valuable indication of the ability of the building to keep people safe, reduce damage and to restore operations after a major earthquake.

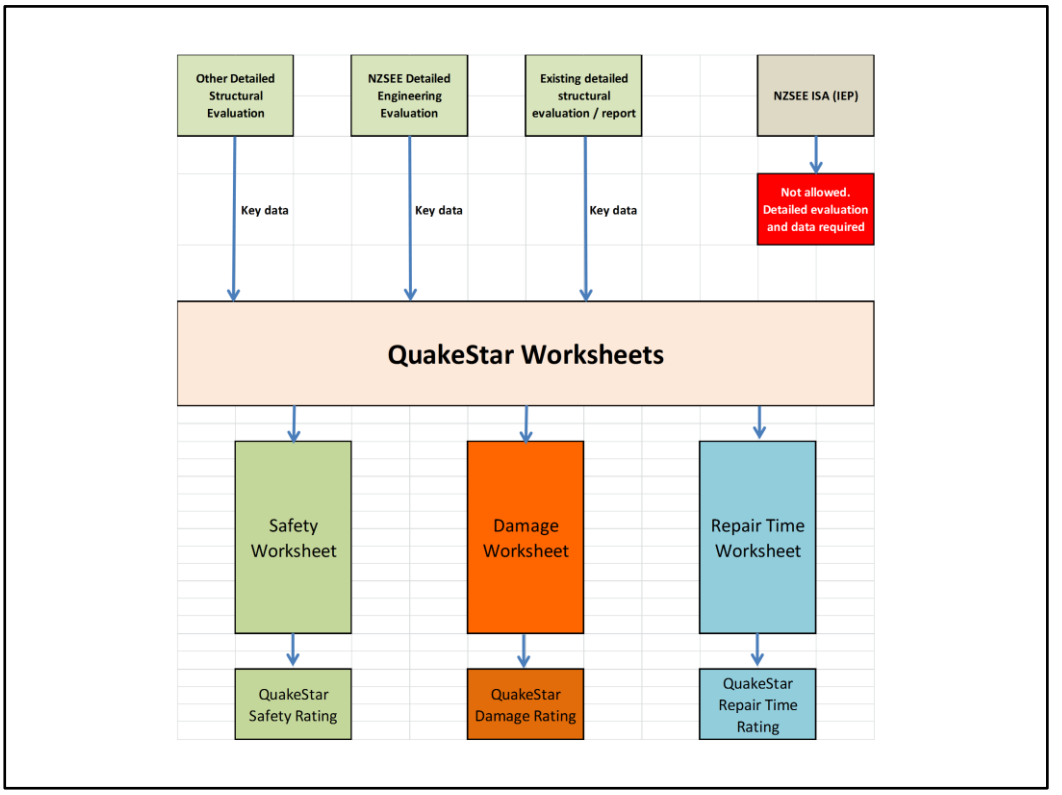
The ratings are based on the assessments of experienced engineers and are intended as an overall guide to help owners, tenants, insurers and others differentiate between buildings at a “headline” level.

They give a *general indication* of expected performance of the building, but due to the highly variable nature of ground shaking and building response in a real earthquake the ratings *cannot be regarded in any way as being a prediction* of performance in a particular event.



The QuakeStar approach achieves consistency by requiring an independent review of the assessments and ratings.

- The owner appoints an Assessing Engineer (on a QuakeStar-approved list of individuals) who examines the site and the building and reviews the design documents, especially structural drawings.
- The Assessing Engineer uses QuakeStar Worksheets to assign the star-ratings for Safety, Damage and Repair Time.
- The owner appoints a Reviewing Engineer (approved as independent by QuakeStar) who reviews the assessment and the ratings of the Assessing Engineer.
- The Assessing Engineer and Reviewing Engineer must then compare notes and agree on each of the three ratings. (They do not have to agree on the detailed reasons).
- The owner receives the agreed ratings and reviews the reports from both the Assessing Engineer and the Reviewing Engineer. If it is clear that ratings would increase if identified improvements were made, the owner may choose to take action on these and ask the engineers to update their ratings.
- The owner then applies for ratification of the ratings by QuakeStar Office.
- Once ratified the basic ratings, but not the engineers' reports, are available to all on the QuakeStar website.
- QuakeStar has an office, a website and a Governing Board. A Technical Advisory Panel reviews building ratings and approves Assessing and Reviewing Engineers.



Engineers enter key results of their assessments into QuakeStar Worksheets which convert the numbers into star-ratings.

The assessments need to be in sufficient depth to give confidence in the values used. The approach may vary from simple static analyses for simple buildings to sophisticated computer analyses for large and complex buildings.

It is not expected that the Initial Assessment Procedure (IAP) of the NZSEE would be sufficient for an authoritative assessment but may provide and indication of likely rating and identify key concerns.

QuakeStar Worksheets

Converting structural assessment data into star-ratings

- *Separate* ratings for Safety Damage Repair Time
- Minimal input required to complete worksheets
- Focus on vital earthquake performance characteristics
  - Detailed assessment needed of site and building
  - Data allowed from any credible source – eg existing reports
  - Engineering judgement needed to determine a score
- Score determines star-rating according to data entered
- Worksheets show star- rating interactively – as scores are entered

Any recognised approach for assessment for the purpose of the Safety Rating may be used, including results from past assessments. These must be shown to be compatible with the preferred approach - the NZSEE Guidelines for the Assessment and Improvement of the Structural Performance of Buildings in Earthquake.

Assessment of Damage and Repair Times may be made using any recognised approach. This includes approaches such as the FEMA P58 Methodology developed in USA or HAZUS. Less detailed methods may be used.

The assessment of Damage and Repair Times is not a precise exercise and the process relies on use of credible data and the agreement between the Assessing and Reviewing Engineers – both of whom must have knowledge and experience in estimating timeframes for building construction.

Why have a rating system?

- *Improve safety of users and public*
  - *Market-driven retrofitting*
  - *New designs to above minimum standards*
- *Improve resilience of buildings and cities/towns*
  - *Lower damage / Less disruption*
  - *Quicker recovery / return to productivity*
- *Improve awareness of owners/users/public*
  - *Recognition that we live with earthquake risk*
  - *Improved earthquake risk management*
  - *Market value for good earthquake engineering*

The proposed QuakeStar rating system aims to bring about changes in market approach to earthquake engineering and improve owner /user/public awareness of the value of earthquake engineering. In particular to:

- *Promote higher standards of retrofit and new design*
- *Highlight the existence of low-rated buildings as a tolerable risk*
- *Promote discussion and consideration of community resilience – through the damage and repair time ratings*
- *Promote more informed and rational decisions on retrofit requirements and timeframes.*
- *Help the property market to put a value on earthquake performance*

Over time this will result in improved public safety; improved resilience of buildings and cities; improved ability of owners and users to manage earthquake risk.

Who are the ratings for?

QuakeStar ratings are designed to differentiate between buildings and to help:

- *Tenants and prospective tenants*
- *Building owners, sellers and buyers*
- *Insurers and funders of buildings*
- *Territorial authorities*
- *Employers (with Health and Safety obligations)*
- *Building users and the general public*

As QuakeStar ratings become more common in the property market, questions about earthquake performance will always be asked in purchase, rental, insurance and funding transactions. Territorial authorities will gain better knowledge of the overall earthquake risks.

The market will thus put a value on the assessed earthquake performance of buildings. Strengthening of buildings will be rewarded by higher market valuation. The costs involved will be seen as an investment, not simply added cost. When the market rewards better earthquake performance, owners would not need to wait for a major earthquake to obtain benefit from their investment.

Such an outcome would be fitting legacy of the Canterbury earthquakes. Owners, tenants and the public would be more aware of earthquake risks, be better able to manage them and be more informed on the role of engineering in mitigating them.

QuakeStar ratings

- Use only *vital earthquake characteristics*
- Are *not a prediction* – they are indicative only
- Provide a *basis for comparison* with other NZ buildings
- Are *derived from %NBS assessments……*

….but in addition:

- Deliver *improved consistency and credibility*
- Give *higher star-ratings when higher design standards are used.*

The QuakeStar approach is to use the data on the fundamental aspects that influence earthquake performance.

The ratings are intended as a guide for the property industry as a high-level means of distinguishing between buildings. Interested parties would still need to review detailed reports on earthquake aspects (as they would for other attributes such as finishes or energy efficiency).

Having a rating to distinguish between buildings has the advantage of raising *and sustaining* awareness of earthquake risk and thus prompting owner and user response.

There is a danger that the ratings are seen as a prediction of performance in a real earthquake . Owners and users may thus be upset if actual performance does not match rated performance. Buildings are usually one-of-a kind. Even two seemingly identical buildings can respond differently to the same earthquake shaking. QuakeStar ratings represent the average expectations of performance of a group of identical buildings. Performance of individual buildings in the group will vary markedly – even if subject to the same shaking.

The challenge is for the community to see the advantages of sustained awareness of earthquake risk while at the same time accepting that prediction of performance of a particular building is well-nigh impossible.

More stars for higher design standards

Comparison of %NBS and QuakeStar Safety Scores

Building Importance Level (IL)	Typical example	Seismic Factor for New Building Standard	%NBS for building to New Building Standard	QuakeStar Safety Score	QuakeStar Safety Rating
IL2	Office Building	1.0	100%NBS	100 - 130	***
IL3	School	1.3	100%NBS	130 - 170	****
IL4	Hospital	1.8	100%NBS	180 - 230	*****

The New Zealand code for structural design sets requirements for different types of building, depending on their importance to the community. Office and commercial buildings are designated as Importance Level 2 (IL2). Buildings such as schools are IL3 and important buildings such as hospitals and fire stations are designated as IL4.

The earthquake design levels for these buildings differs markedly. For IL2 earthquake "loading" is factored by 1.0. For IL3 the factor is 1.3 and for IL4 the factor is 1.8. These factors reflect the increase in intensity of expected ground shaking as the probability reduces. For IL2, 500-year shaking is used, for IL3 1000-year and for IL4 2500-year shaking.

This means that the New Building Standard (NBS) is different for each importance level. Thus a hospital at 100%NBS (of IL4 requirements) is 80% "stronger" than an office building at 100%NBS.

QuakeStar takes account of these differences by assigning higher scores for IL3 and IL4 buildings.

These differences highlight the fact that the New Building Standard is a minimum requirement – there is nothing to prevent owners from designing to higher levels. For example, an office building (IL2) designed to IL4 requirements would have a score of 180 and result in a 5-star Safety Rating.

Some indicative examples

Real buildings: Based on existing reports and only partial information

QuakeStar Preliminary Assessments Summary - Office Buildings

Building	Design	%NBS	QuakeStar Score	QuakeStar Ratings			External Factors	Comment
				Safety	Damage	Repair		
1	1950s	60	62	*	**	*	3	Robust MWD design but dated
2	1987	100	121	***	***	**	4	Stair details not checked.
3	1988	100	133	***	**	**	4	Assumes no issues with floor support
4	Late 70s	75	100	**	**	*	5	Limited by façade detailing. *** otherwise.
5	1996	65	71	**	**	*	4	Damage issues with floors and reclaimed site
6	1973	90	88	**	**	**	5	Issues with separation, stairs
7	1973/2004	80	97	**	**	*	3	Close to *** on Safety
8	1986	65	54	*	**	*	2	Separation, column capacities
9	1986	90	73	*	**	*	2	Stair issues. Otherwise **.
10	1979/2004	100	100	**	*	*	4	Safety *** with no issues on stairs / floors
11	2009	100	107	***	**	*	6	
12	2002	133	161	***	****	**	4	133%NBS means low impact at 500yr shaking
13	1989	120	145	***	***	**	4	
14	1986	110	96	**	**	**	3	Issues with diaphragms / blockwall separation
15	Late 70s	110	80	**	**	*	3	Issues with floor supports and column detailing
16	70s /2007	100	110	***	***	**	3	

This table shows some indicative ratings based on existing assessments of some existing multi-storey buildings. Not every aspect has been assessed to meet QuakeStar requirements but the table gives an indication of how buildings of different types and ages would rate.

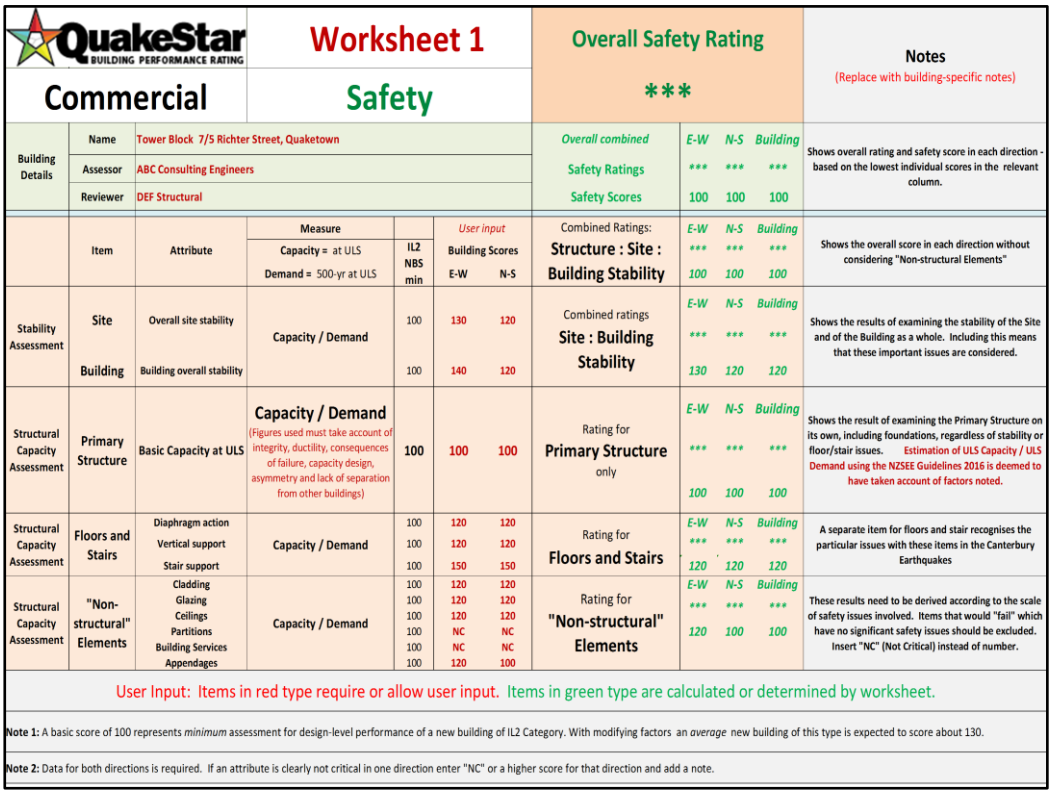
Some indicative examples

Imaginary buildings – including possible new designs

QuakeStar Preliminary Assessments Summary

Building	Design	%NBS	QuakeStar Score	QuakeStar Ratings			External Factors	Comment
				Safety	Damage	Repair		
URM40	1930	40	30		*	*	na	URM with 40%NBS
URM 50	1930	50	40	*	*	*	na	URM with 50%NBS
Pre 65 RC	1960	50	45	*	*	*	na	Pre 1965 Reinforced Concrete with 50%NBS
2015 IL2	2015	100	130	***	**	*	na	New IL2 Design - conventional
2015 IL2 - BI	2015	100	130	***	****	**	na	New IL2 Design - with Base Isolation
2015 IL3	2015	100	170	****	***	**	na	New IL3 Design - conventional
2015 IL3 - BI	2015	100	170	****	*****	***	na	New IL3 Design - with Base Isolation
2015 IL4	2015	100	230	*****	***	***	na	New IL4 Design - conventional
2015 BI IL4	2015	100	230	*****	*****	****	na	New IL4 Design - with Base Isolation

This table shows some hypothetical examples to illustrate the full range of ratings – from a low-rated old brick building (URM40) to a modern building designed to IL4 requirements with the additional benefit of base-isolation which rates 5-star for Safety, Damage and Repair Time.



QuakeStar BUILDING PERFORMANCE RATING

Commercial

Worksheet 1

Safety

Overall Safety Rating

***

Notes
(Replace with building-specific notes)

Building Details		
Name	Tower Block 7/5 Richter Street, Quaketown	
Assessor	ABC Consulting Engineers	
Reviewer	DEF Structural	

	Overall combined	E-W	N-S	Building
	Safety Ratings	***	***	***
	Safety Scores	100	100	100

Shows overall rating and safety score in each direction - based on the lowest individual scores in the relevant column.

	Item	Attribute	Measure		IL2 NBS min	User input Building Scores E-W	N-S
			Capacity = at ULS				
			Demand = 500-yr at ULS				
Stability Assessment	Site	Overall site stability	Capacity / Demand		100	130	120
	Building	Building overall stability			100	140	120
Structural Capacity Assessment	Primary Structure	Basic Capacity at ULS	Capacity / Demand (Figures used must take account of integrity, ductility, consequences of failure, capacity design, asymmetry and lack of separation from other buildings)		100	100	100
Structural Capacity Assessment	Floors and Stairs	Diaphragm action	Capacity / Demand		100	120	120
		Vertical support			100	120	120
		Stair support			100	150	150
Structural Capacity Assessment	"Non-structural" Elements	Cladding	Capacity / Demand		100	120	120
		Glazing			100	120	120
		Ceilings			100	120	120
		Partitions			100	NC	NC
		Building Services			100	NC	NC
		Appendages			100	120	100

Combined Ratings:	E-W	N-S	Building
Structure : Site : Building Stability	***	***	***
	100	100	100

Shows the overall score in each direction without considering "Non-structural Elements"

Combined ratings	E-W	N-S	Building
Site : Building Stability	***	***	***
	130	120	120

Shows the results of examining the stability of the Site and of the Building as a whole. Including this means that these important issues are considered.

Rating for	E-W	N-S	Building
Primary Structure only	***	***	***
	100	100	100

Shows the result of examining the Primary Structure on its own, including foundations, regardless of stability or floor/stair issues. Estimation of ULS Capacity / ULS Demand using the NZSEE Guidelines 2016 is deemed to have taken account of factors noted.

Rating for	E-W	N-S	Building
Floors and Stairs	***	***	***
	120	120	120

A separate item for floors and stair recognises the particular issues with these items in the Canterbury Earthquakes

Rating for	E-W	N-S	Building
"Non-structural" Elements	***	***	***
	120	100	100

These results need to be derived according to the scale of safety issues involved. Items that would "fail" which have no significant safety issues should be excluded. Insert "NC" (Not Critical) instead of number.

User Input: Items in red type require or allow user input. Items in green type are calculated or determined by worksheet.

Note 1: A basic score of 100 represents *minimum* assessment for design-level performance of a new building of IL2 Category. With modifying factors an *average* new building of this type is expected to score about 130.

Note 2: Data for both directions is required. If an attribute is clearly not critical in one direction enter "NC" or a higher score for that direction and add a note.

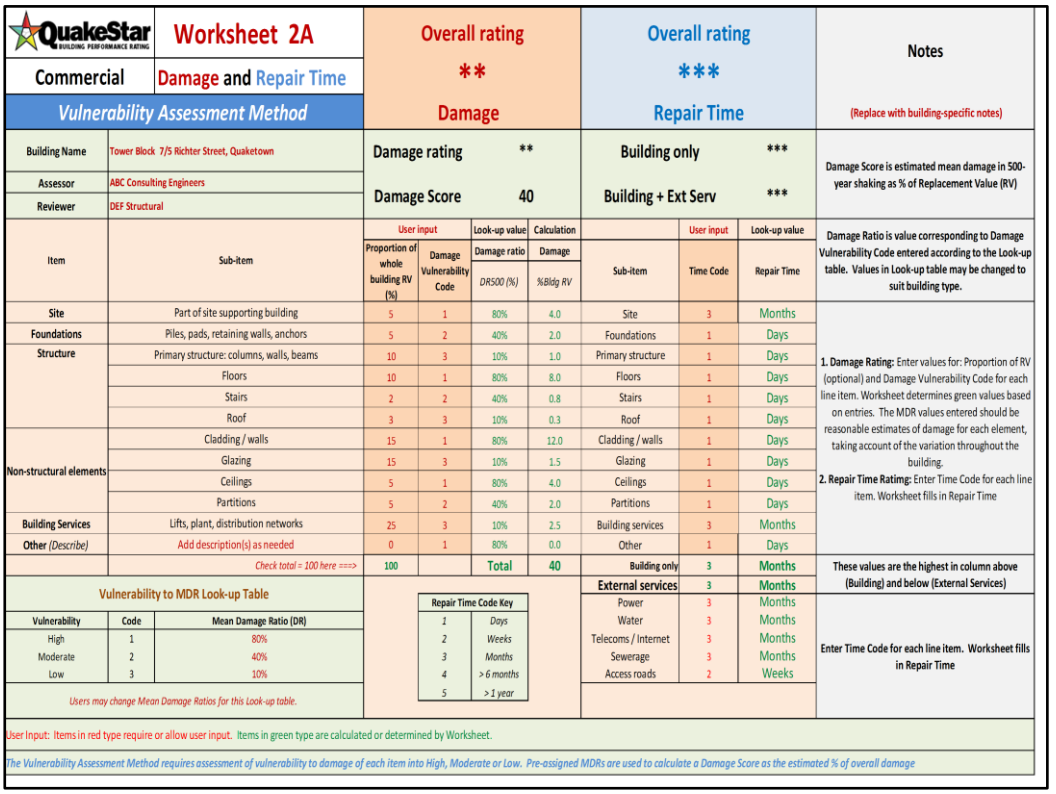
Commercial Buildings

Safety Worksheet – interactive Excel spreadsheet

Engineers enter figures in the “User input” columns based on their assessments. These figures are essentially the %NBS figures for each, adjusted for building importance.

The Worksheet examines those figures and assigns a Overall Safety Rating based on the lowest values in each section and then overall.

The Safety Worksheet provides a one-page overview of the building from which it is easy to identify critical items that are reducing the rating.



QuakeStar BUILDING PERFORMANCE RATING

Worksheet 2A

Commercial — Damage and Repair Time

Vulnerability Assessment Method

Building Name	Tower Block 7/5 Richter Street, Quaketown
Assessor	ABC Consulting Engineers
Reviewer	DEF Structural

Overall rating **

Damage

Damage rating **

Damage Score 40

Overall rating ***

Repair Time

Building only ***

Building + Ext Serv ***

Notes

(Replace with building-specific notes)

Damage Score is estimated mean damage in 500-year shaking as % of Replacement Value (RV)

Item	Sub-item	User input: Proportion of whole building RV (%)	User input: Damage Vulnerability Code	Look-up value: Damage ratio DR500 (%)	Calculation: Damage %Bldg RV
Site	Part of site supporting building	5	1	80%	4.0
Foundations	Piles, pads, retaining walls, anchors	5	2	40%	2.0
Structure	Primary structure: columns, walls, beams	10	3	10%	1.0
	Floors	10	1	80%	8.0
	Stairs	2	2	40%	0.8
	Roof	3	3	10%	0.3
Non-structural elements	Cladding / walls	15	1	80%	12.0
	Glazing	15	3	10%	1.5
	Ceilings	5	1	80%	4.0
	Partitions	5	2	40%	2.0
Building Services	Lifts, plant, distribution networks	25	3	10%	2.5
Other *(Describe)*	Add description(s) as needed	0	1	80%	0.0
	Check total = 100 here ===>	100		Total	40

Sub-item	User input: Time Code	Look-up value: Repair Time
Site	3	Months
Foundations	1	Days
Primary structure	1	Days
Floors	1	Days
Stairs	1	Days
Roof	1	Days
Cladding / walls	1	Days
Glazing	1	Days
Ceilings	1	Days
Partitions	1	Days
Building services	3	Months
Other	1	Days
Building only	3	Months
External services	3	Months
Power	3	Months
Water	3	Months
Telecoms / Internet	3	Months
Sewerage	3	Months
Access roads	2	Weeks

Damage Ratio is value corresponding to Damage Vulnerability Code entered according to the Look-up table. Values in Look-up table may be changed to suit building type.

1. Damage Rating: Enter values for: Proportion of RV (optional) and Damage Vulnerability Code for each line item. Worksheet determines green values based on entries. The MDR values entered should be reasonable estimates of damage for each element, taking account of the variation throughout the building.

2. Repair Time Ratimg: Enter Time Code for each line item. Worksheet fills in Repair Time

These values are the highest in column above (Building) and below (External Services)

Enter Time Code for each line item. Worksheet fills in Repair Time

Vulnerability to MDR Look-up Table

Vulnerability	Code	Mean Damage Ratio (DR)
High	1	80%
Moderate	2	40%
Low	3	10%

Users may change Mean Damage Ratios for this Look-up table.

Repair Time Code Key	
1	Days
2	Weeks
3	Months
4	> 6 months
5	> 1 year

User Input: Items in red type require or allow user input. Items in green type are calculated or determined by Worksheet.

The Vulnerability Assessment Method requires assessment of vulnerability to damage of each item into High, Moderate or Low. Pre-assigned MDRs are used to calculate a Damage Score as the estimated % of overall damage

Commercial Buildings

Damage and Repair Time Worksheet 2A – interactive Excel spreadsheet
Vulnerability Method

Engineers enter values in the User Input columns for Damage and Repair Time.

Damage Worksheet
This is one of two methods, the Vulnerability Method and the Damage Ratio Method (see next slide). In this *Vulnerability Method* the engineer is required only to rate each element as High, Moderate or Low vulnerability to the effects of 500-year shaking on the building. Pre-assigned values are used to compute the estimate damage. Users may alter the pre-assigned values if they wish.

The Worksheet computes an estimate of overall damage based on entered values and assigns the Damage Rating accordingly.

Repair Time Worksheet
Engineers are required to assess the time from start of design work through to completion of the stated item. They then enter a code (1-5 in red) to match the assessed time – which then appears in the Repair Time column. The Worksheet then looks for the longest time and assigns the star rating based on that.

The effect of *External Services* supplying the building is included and the ratings made with and without considering these.

QuakeStar BUILDING PERFORMANCE RATING — Worksheet 2B

Commercial — Damage and Repair Time

Mean Damage Ratio Method

Overall rating	Overall rating	Notes
**	***	(Replace with building-specific notes)
Damage	Repair Time	

Building Name	Tower Block 7/5 Richter Street, Quaketown	Damage rating	**	Building only	***	Damage Score is estimated mean damage in 500-year shaking as % of Replacement Value (RV)		
Assessor	ABC Consulting Engineers	Damage Score	35	Building + Ext Serv	***			
Reviewer	DEF Structural							

Item	Sub-item	User input: Proportion of whole building RV (%)	Look-up value: Damage ratio DR500 (%)	Calculation: Damage %Bldg RV	Sub-item	User input: Time Code	Look-up value: Repair Time
Site	Part of site supporting building	5	20%	1.0	Site	3	Months
Foundations	Piles, pads, retaining walls, anchors	5	30%	1.5	Foundations	1	Days
Structure	Primary structure: columns, walls, beams	10	50%	5.0	Primary structure	1	Days
	Floors	10	40%	4.0	Floors	1	Days
	Stairs	2	60%	1.2	Stairs	1	Days
	Roof	3	5%	0.2	Roof	1	Days
Non-structural elements	Cladding / walls	15	30%	4.5	Cladding / walls	1	Days
	Glazing	15	8%	1.2	Glazing	1	Days
	Ceilings	5	20%	1.0	Ceilings	1	Days
	Partitions	5	30%	1.5	Partitions	1	Days
Building Services	Lifts, plant, distribution networks	25	50%	12.5	Building services	3	Months
Other (Describe)	Add description(s) as needed	0	0%	0.0	Other	1	Days
	Check total = 100 here ===>	100	Total	35	Building only	3	Months
					External services	3	Months

1. **Damage Rating:** Enter values for: Proportion of RV (optional) and Mean Damage Ratio for each line item. Worksheet determines green values based on entries. The MDR values entered should be reasonable estimates of damage for each element, taking account of the variation throughout the building.
2. **Repair Time Rating:** Enter Time Code for each line item. Worksheet fills in Repair Time

These values are the highest in column above (Building) and below (External Services)

Repair Time Code Key	
1	Days
2	Weeks
3	Months
4	> 6 months
5	> 1 year

Power	3	Months
Water	3	Months
Telecoms / Internet	3	Months
Sewerage	3	Months
Access roads	2	Weeks

Enter Time Code for each line item. Worksheet fills in Repair Time

Note

This Mean Damage Ratio Method relies on determination of MDR % values from PACT, REDi, HAZUS or other recognised and credible sources.

User Input: Items in red type require or allow user input. Items in green type are calculated or determined by Worksheet.

The Mean Damage Ratio Method allows users to determine Mean Damage Ratios by any recognised means and enter the values directly. These MDRs are used to calculate a Damage Score as the estimated % of overall damage

Commercial Buildings

Damage and Repair Time Worksheet 2B - interactive Excel spreadsheet
Damage Ratio Method

Assessors enter values in the User Input columns for Damage and Repair Time. The Worksheet assigns star ratings based on the figures entered.

Damage Worksheet
This is one of two methods, the Vulnerability Method and the Damage Ratio Method (see next slide). In this *Damage Ratio Method* the engineer enters damage ratio assessments for each item based on the effects of 500-year shaking on the building. Any recognised source of damage estimates may be used, for example HAZUS.

The Worksheet computes an estimate of overall damage based on entered values and assigns the Damage Rating accordingly.

Repair Time Worksheet
Engineers are required to assess the time from start of design work through to completion of the stated item. They then enter a code (1-5 in red) to match the assessed time – which then appears in the Repair Time column. The Worksheet then looks for the longest time and assigns the star rating based on that.

The effect of *External Services* supplying the building is included and the ratings made with and without considering these.

QuakeStar BUILDING PERFORMANCE RATING	Worksheet 3	Issues of potential concern identified	Adjacent Buildings: Impact on Rating		
			Safety	Damage	Repair
Commercial	External Factor Record	4	☆	☆	☆

Building Name	Tower Block 7/5 Richter Street, Quaketown		*Note: If the potential impact of adjacent buildings (or other external factors) is significant, assess the impact on the star-rating of the building and record the number of stars by which the rating would be reduced. The star-rating for the building will remain as shown on Worksheets 1 and 2 but the potential impact of the External Factors will be represented by hollow stars rather than fully shaded ones.*
Assessor	ABC Consulting Engineers		
Reviewer	DEF Structural		
External Factor	Score	*Enter Score and then comment on evidence / lack of evidence of any issues beyond the subject site that could have significant influence on Safety, Damage or Repair / Down time. Qualitative comment only needed - enough to alert owner / prospective purchaser of potential concern.* Comment	Notes
Adjacent buildings / sites	1	Building to North is URM. Collapse of parts could well occur in 500-year shaking and pose a safety risk, cause damage and increase repair time.	
Earthquake Fault Movement	1	Site remote from known faults. No issues.	
Landslip / Boulder Roll	0	Site not shown to be subject to risk on Council maps. No issues.	
Liquefaction / Lateral spreading	1	Potential for minor liquefaction / lateral spreading movement on adjacent sites. Unlikely to be a safety or damage concern but repair time could be affected.	
Utilities	0	No evidence of special measures to protect incoming utilities from expected differential movement. No safety or damage issues but repair / reinstatement of operations could be delayed.	
Site access	1	Liquefaction potential and landslip risk to major roads essential to building function. Could affect time to reinstate function but no safety or damage issues.	
Tsunami / Flooding	0	Site not shown to be subject to risk on Council maps. No issues.	
Scoring system (for each heading)		Evidence of effective protection measures **or** evidence that risk is not present **or** that effects are insignificant: Score = 0; Otherwise, Score =1.	
User Input: Items in red type require or allow user input.			

Commercial Buildings

External Factor Worksheet – interactive Excel spreadsheet

Factors beyond the subject site can influence the earthquake performance of a building. For example, a vulnerable building next door may collapse on to the subject building. It is difficult and not practicable to assess the likely effects of the External Factors on the rating of the subject building. The External Factor sheet allows engineers to record the existence or not of the listed external factors and to make notes for information of interested parties.

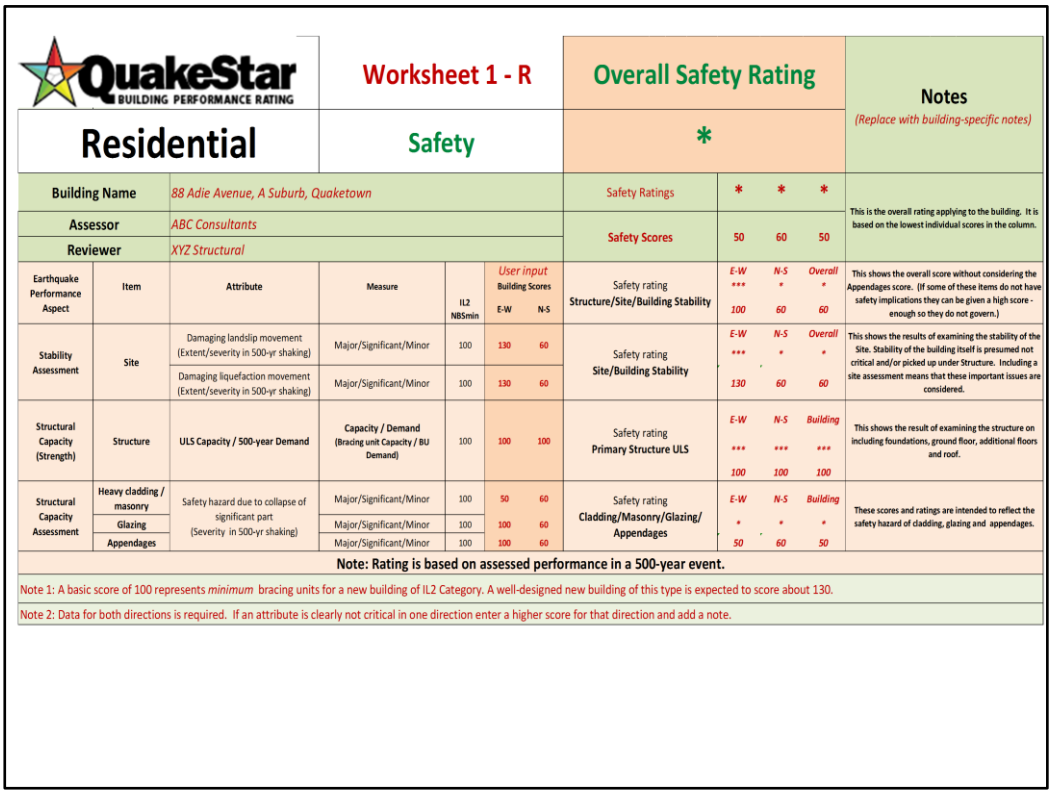
However the External Factor sheet asks engineers to broadly assess the reduction in rating, for each of Safety, Damage and Repair Time, that would result from the worst External Factor effect. They indicate this at the top right of the sheet.

The ratings for Safety, Damage and Repair Time remain unchanged but where there is an External Factor effect, the reduction in rating is indicated by displaying the stars as hollow rather than solid.

For example, if a reduction of two stars was identified for External Factors:

A 3-star rating: ★★★

Would be shown as: ★☆☆



QuakeStar BUILDING PERFORMANCE RATING

Residential

Worksheet 1 - R

Safety

Overall Safety Rating

*

Notes

(Replace with building-specific notes)

Building Name	*88 Adie Avenue, A Suburb, Quaketown*
Assessor	*ABC Consultants*
Reviewer	*XYZ Structural*

Safety Ratings	*	*	*
Safety Scores	50	60	50

This is the overall rating applying to the building. It is based on the lowest individual scores in the column.

Earthquake Performance Aspect	Item	Attribute	Measure	IL2 NBSmin	User input Building Scores E-W	N-S			
							Safety rating	E-W	N-S	Overall	Notes
							Structure/Site/Building Stability	*** 100	* 60	* 60	This shows the overall score without considering the Appendages score. (If some of these items do not have safety implications they can be given a high score - enough so they do not govern.)
Stability Assessment	**Site**	Damaging landslip movement (Extent/severity in 500-yr shaking)	Major/Significant/Minor	100	130	60	Safety rating **Site/Building Stability**	E-W *** 130	N-S * 60	Overall * 60	This shows the results of examining the stability of the Site. Stability of the building itself is presumed not critical and/or picked up under Structure. Including a site assessment means that these important issues are considered.
		Damaging liquefaction movement (Extent/severity in 500-yr shaking)	Major/Significant/Minor	100	130	60					
Structural Capacity (Strength)	**Structure**	**ULS Capacity / 500-year Demand**	**Capacity / Demand (Bracing unit Capacity / BU Demand)**	100	100	100	Safety rating **Primary Structure ULS**	E-W *** 100	N-S *** 100	Building *** 100	This shows the result of examining the structure on including foundations, ground floor, additional floors and roof.
Structural Capacity Assessment	**Heavy cladding / masonry**	Safety hazard due to collapse of significant part (Severity in 500-yr shaking)	Major/Significant/Minor	100	50	60	Safety rating **Cladding/Masonry/Glazing/ Appendages**	E-W * 50	N-S * 60	Building * 50	These scores and ratings are intended to reflect the safety hazard of cladding, glazing and appendages.
	Glazing		Major/Significant/Minor	100	100	60					
	Appendages		Major/Significant/Minor	100	100	60					

Note: Rating is based on assessed performance in a 500-year event.

Note 1: A basic score of 100 represents *minimum* bracing units for a new building of IL2 Category. A well-designed new building of this type is expected to score about 130.

Note 2: Data for both directions is required. If an attribute is clearly not critical in one direction enter a higher score for that direction and add a note.

Residential Buildings

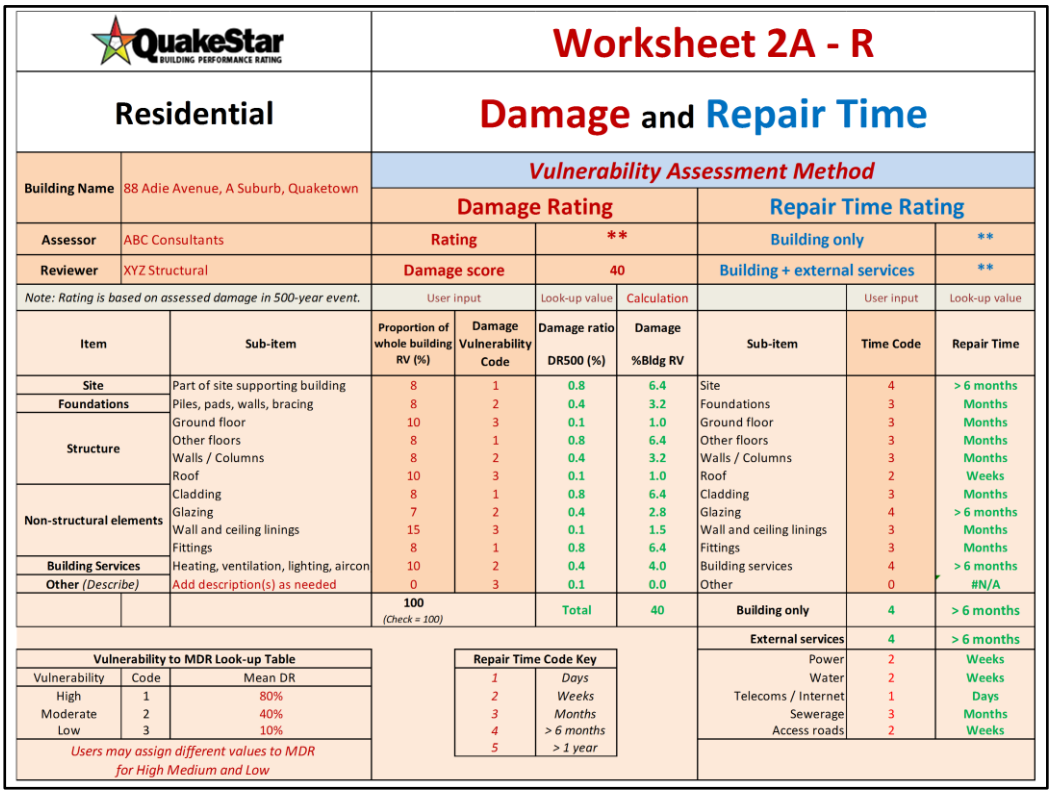
Safety Worksheet 1-R – interactive Excel Worksheet

The QuakeStar Residential Worksheets are used in a similar way to the corresponding Commercial Worksheets.

They are designed to apply to small residential buildings such as houses and low-rise apartment blocks.

Values entered on this Safety Worksheet are the %NBS values for each item adjusted for building importance if the building is used for IL3 or IL4 purposes.

Values for each direction are required. The spreadsheet examines the values entered and determines the rating based on the lowest value in each category and then overall.



QuakeStar BUILDING PERFORMANCE RATING

Worksheet 2A - R

Residential

Damage and Repair Time

Building Name	88 Adie Avenue, A Suburb, Quaketown	*Vulnerability Assessment Method*							
		Damage Rating				**Repair Time Rating**			
Assessor	ABC Consultants	**Rating**			**	**Building only**			**
Reviewer	XYZ Structural	**Damage score**			40	**Building + external services**			**
Note: Rating is based on assessed damage in 500-year event.		User input		Look-up value	Calculation			User input	Look-up value
Item	**Sub-item**	**Proportion of whole building RV (%)**	**Damage Vulnerability Code**	**Damage ratio DR500 (%)**	**Damage %Bldg RV**	**Sub-item**	**Time Code**	**Repair Time**	
Site	Part of site supporting building	8	1	0.8	6.4	Site	4	> 6 months	
Foundations	Piles, pads, walls, bracing	8	2	0.4	3.2	Foundations	3	Months	
Structure	Ground floor	10	3	0.1	1.0	Ground floor	3	Months	
	Other floors	8	1	0.8	6.4	Other floors	3	Months	
	Walls / Columns	8	2	0.4	3.2	Walls / Columns	3	Months	
	Roof	10	3	0.1	1.0	Roof	2	Weeks	
Non-structural elements	Cladding	8	1	0.8	6.4	Cladding	3	Months	
	Glazing	7	2	0.4	2.8	Glazing	4	> 6 months	
	Wall and ceiling linings	15	3	0.1	1.5	Wall and ceiling linings	3	Months	
	Fittings	8	1	0.8	6.4	Fittings	3	Months	
Building Services	Heating, ventilation, lighting, aircon	10	2	0.4	4.0	Building services	4	> 6 months	
Other *(Describe)*	Add description(s) as needed	0	3	0.1	0.0	Other	0	#N/A	
		100 *(Check = 100)*		Total	40	**Building only**	4	> 6 months	
						External services	4	> 6 months	
						Power	2	Weeks	
						Water	2	Weeks	
						Telecoms / Internet	1	Days	
						Sewerage	3	Months	
						Access roads	2	Weeks	

Vulnerability to MDR Look-up Table		
Vulnerability	Code	Mean DR
High	1	80%
Moderate	2	40%
Low	3	10%
Users may assign different values to MDR for High Medium and Low		

Repair Time Code Key	
1	*Days*
2	*Weeks*
3	*Months*
4	*> 6 months*
5	*> 1 year*

Residential Buildings

Damage and Repair Time Worksheet 2A-R – interactive Excel Worksheet
Vulnerability Method

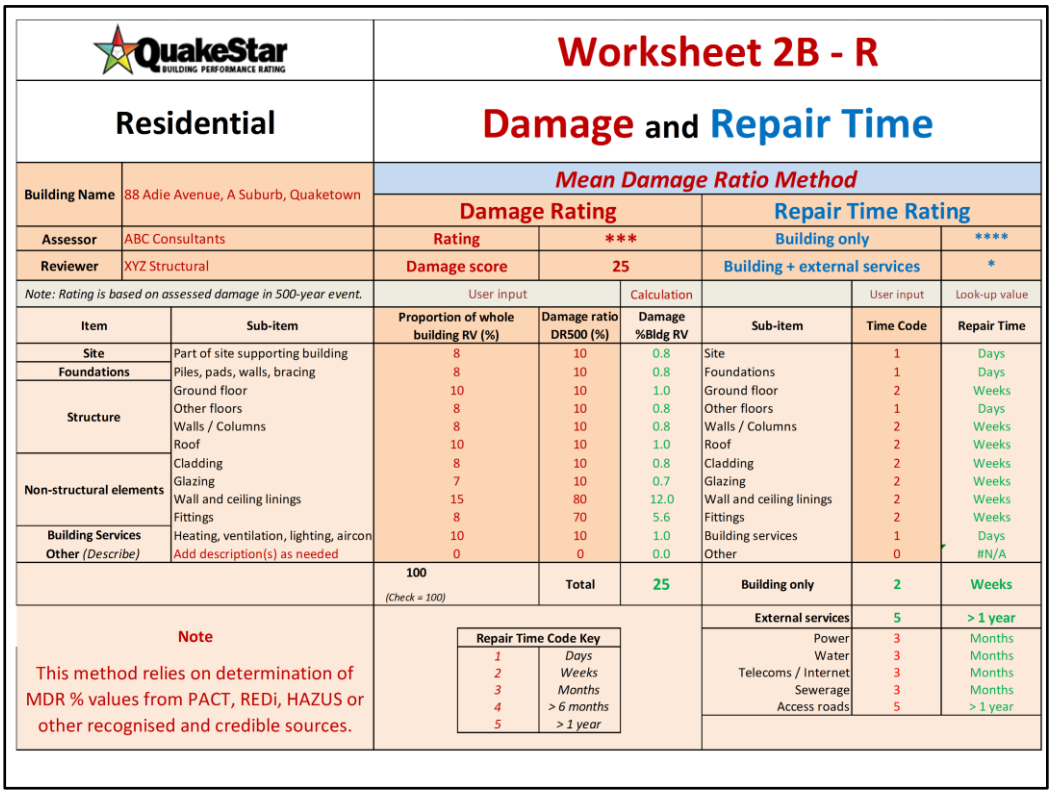
Assessors enter values in the User Input columns for Damage and Repair Time. The Worksheet assigns star ratings based on the figures entered.

Damage Worksheet
This is one of two methods, the Vulnerability Method and the Damage Ratio Method (see next slide). In this *Vulnerability Method* the engineer is required only to rate each element as High, Moderate or Low vulnerability to the effects of 500-year shaking on the building. Pre-assigned values are used to compute the estimate damage. Users may alter the pre-assigned values if they wish.

The Worksheet computes an estimate of overall damage based on entered values and assigns the Damage Rating accordingly.

Repair Time Worksheet
Engineers are required to assess the time from start of design work through to completion of the stated item. They then enter a code (1-5 in red) to match the assessed time – which then appears in the Repair Time column. The Worksheet then looks for the longest time and assigns the star rating based on that.

The effect of *External Services* supplying the building is included and the ratings made with and without considering these.



QuakeStar BUILDING PERFORMANCE RATING

Residential

Worksheet 2B - R

Damage and Repair Time

Mean Damage Ratio Method

Building Name	88 Adie Avenue, A Suburb, Quaketown
Assessor	ABC Consultants
Reviewer	XYZ Structural

Note: Rating is based on assessed damage in 500-year event.

Damage Rating

Rating	***
Damage score	25

Repair Time Rating

Building only	****
Building + external services	*

Item	Sub-item	User input: Proportion of whole building RV (%)	User input: Damage ratio DR500 (%)	Calculation: Damage %Bldg RV
Site	Part of site supporting building	8	10	0.8
Foundations	Piles, pads, walls, bracing	8	10	0.8
Structure	Ground floor	10	10	1.0
	Other floors	8	10	0.8
	Walls / Columns	8	10	0.8
	Roof	10	10	1.0
Non-structural elements	Cladding	8	10	0.8
	Glazing	7	10	0.7
	Wall and ceiling linings	15	80	12.0
	Fittings	8	70	5.6
Building Services	Heating, ventilation, lighting, aircon	10	10	1.0
Other *(Describe)*	Add description(s) as needed	0	0	0.0
		100 *(Check = 100)*	Total	25

Sub-item	User input: Time Code	Look-up value: Repair Time
Site	1	Days
Foundations	1	Days
Ground floor	2	Weeks
Other floors	1	Days
Walls / Columns	2	Weeks
Roof	2	Weeks
Cladding	2	Weeks
Glazing	2	Weeks
Wall and ceiling linings	2	Weeks
Fittings	2	Weeks
Building services	1	Days
Other	0	#N/A
Building only	2	Weeks
External services	5	> 1 year
Power	3	Months
Water	3	Months
Telecoms / Internet	3	Months
Sewerage	3	Months
Access roads	5	> 1 year

Note

This method relies on determination of MDR % values from PACT, REDi, HAZUS or other recognised and credible sources.

Repair Time Code Key	
1	Days
2	Weeks
3	Months
4	> 6 months
5	> 1 year

Residential Buildings

Damage and Repair Time Worksheet 2B-R – interactive Excel Worksheet
Damage Ratio Method

Assessors enter values in the User Input columns for Damage and Repair Time. The Worksheet assigns star ratings based on the figures entered.

Damage Worksheet
This is one of two methods, the Vulnerability Method and the Damage Ratio Method (see next slide). In this *Damage Ratio Method* the engineer enters damage ratio assessments for each item based on the effects of 500-year shaking on the building.

The Worksheet computes an estimate of overall damage based on entered values and assigns the Damage Rating accordingly.

Repair Time Worksheet
Engineers are required to assess the time from start of design work through to completion of the stated item. They then enter a code (1-5 in red) to match the assessed time – which then appears in the Repair Time column. The Worksheet then looks for the longest time and assigns the star rating based on that.

The effect of *External Services* supplying the building is included and the ratings made with and without considering these.

QuakeStar BUILDING PERFORMANCE RATING	Worksheet 3 - R	Issues of potential concern identified	Impact on Rating - Adjacent buildings and other factors		
			Damage	Damage	Repair
Residential	External Factor Record	4	☆	☆	☆

Building Name	88 Adie Avenue, A Suburb, Quaketown
Assessor	ABC Consultants
Reviewer	XYZ Structural

If the potential impact of adjacent buildings (or other external factors) is significant, assess the impact on the star-rating of the building and record the number of stars by which the rating would be reduced. The star-rating for the building will remain as shown on Worksheets 1 and 2 but the potential impact of the External Factors will be represented by hollow stars rather than fully shaded ones.

External Factor	Score	Comment	Notes
Adjacent buildings / sites	1	Building to North is URM. Collapse of parts could well occur in 500-year shaking and pose a safety risk, cause damage and increase repair time.	
Earthquake Fault Movement	1	Site remote from known faults. No issues.	
Landslip / Boulder Roll	0	Site not shown to be subject to risk on Council maps. No issues.	
Liquefaction / Lateral spreading	1	Potential for minor liquefaction / lateral spreading movement on adjacent sites. Unlikely to be a safety or damage concern but repair time could be affected.	
Utilities	0	No evidence of special measures to protect incoming utilities from expected differential movement. No safety or damage issues but repair / reinstatement of operations could be delayed.	
Site access	1	Liquefaction potential and landslip risk to major roads essential to building function. Could affect time to reinstate function but no safety or damage issues.	
Tsunami / Flooding	0	Site not shown to be subject to risk on Council maps. No issues.	

Scoring system: Evidence of effective protection measures **OR** evidence that risk is not present **OR** that effects are insignificant: Score = 0; Otherwise, Score =1.

User Input: Items in red type require or allow user input.

Residential Buildings

External Factor Worksheet 3R – interactive Excel spreadsheet

Factors beyond the subject site can influence the earthquake performance of a building. For example, a vulnerable building next door may collapse on to the subject building. It is difficult and not practicable to assess the likely effects of the External Factors on the rating of the subject building. The External Factor Worksheet allows engineers to record the existence or not of the listed external factors and to make notes for information of interested parties.

However the External Factor sheet asks engineers to broadly assess the reduction in rating, for each of Safety, Damage and Repair Time, that would result from the worst External Factor effect. They indicate this at the top right of the sheet.

The ratings for Safety, Damage and Repair Time remain unchanged but where there is an External Factor effect, the reduction in rating is indicated by displaying the stars as hollow rather than solid.

For example, if a reduction of two stars was identified for External Factors:

A 3-star rating: ★★★

Would be shown as: ★☆☆

Summary

A QuakeStar rating system will:

- Extend and improve on %NBS
  - Agreement of two engineers needed
  - Fewer divisions means agreement easier
- Drive higher standards for retrofit and new.
- *Remind that we live with earthquake risk.*
- Improve approaches to managing earthquake risk.
- Be an ongoing reminder that *engineering matters*.
- Be a fitting legacy from the Canterbury Earthquakes

A rating system for New Zealand buildings

Make a comment / Ask a question