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# Evaluation of Liquefaction Based On Shear Wave Velocity Using Machine Learning

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***Abstract*** - Liquefaction investigations use a variety of approaches based on field and laboratory tests. The paper describes a study designed to determine the probability of soil liquefaction in a region covering Turkey and Iraq. We used machine learning approaches, particularly Random Forest (RF) models, to build and test models to estimate the chance of liquefaction, with shear wave velocity playing a critical role. In addition, earthquake magnitude and peak acceleration were considered important variables. The dataset includes soil attributes such as effective vertical stress (σ′v0), soil type, shear wave velocity (Vs), and earthquake parameters including peak horizontal acceleration (PGA) and magnitude (M), allowing for the computation of liquefaction risk as actual values. The results indicate that Random Forest predicted soil liquefaction potential with a remarkable 92.5% accuracy using only 20% of the dataset. This study adds to the progress of risk assessment approaches in earthquake-prone locations, hence improving infrastructure resilience and catastrophe protection.

***Keywords*:** Liquefaction, shear wave velocity, Random Forest, Probability of liquefaction.

## 1. Introduction

The estimation of soil liquefaction potential is a crucial element in geotechnical engineering, particularly in seismically active areas. Liquefaction, the process by which saturated soil loses strength and stiffness due to increasing pore water pressure during earthquakes, can cause significant structural damage and fatalities. Various approaches for assessing liquefaction potential have been developed, including those based on shear wave velocity (Vs), a fundamental feature that reflects soil stiffness and strength.

Numerous investigators have provided various approaches for evaluating liquefaction based on in-situ measurements such as shear wave velocity. [9], [14], [15] [11]. In 1971, following the 1964 Niigata and Alaska earthquakes, Seed and Idriss developed the "simplified method," which determines soil liquefaction potential. Seed et al. (1975a, b, 1983, 1985), [16], improved on this strategy. In the early 2000s, more research was conducted to improve this approach, including studies by [6], [7], [10] and [21].

This study examined liquefaction using field data obtained from Turkey and Iraq. [13] estimating the susceptibility of granular materials to probable liquefaction in Basra using SPT data demonstrated that some locations may experience liquefaction of high supposed earthquake magnitude. Other studies have been done to evaluate liquefaction based on SPT in Halbja north of Iraq [2] and Marmora Regine [16].

The possibility of liquefaction is determined by analysing shear wave velocity (Vs), a key dynamic characteristic of soils. Vs values can be calculated using a variety of methods, including traditional geophysical techniques such as seismic refraction and reflection, as well as borehole geophysical methods such as cross-hole and down-hole measurements. To calculate liquefaction potential (PL), parameters such as effective vertical stress (σ′v0), soil type, and earthquake characteristics are essential. Nevertheless, machine learning plays a vital part in improving liquefaction evaluation processes, thereby reducing both time and costs. It offers an effective set of tools for liquefaction assessments, enabling scientists and engineers to develop accurate, flexible and adaptable models for evaluating liquefaction susceptibility and mitigating seismic risks.

## 2. Tectonic Features

Turkey, located in the Alpine-Himalayan orogenesis, has a long history of significant quakes across the North Anatolian Fault zone due to its tectonic zones. According to Ketin (1948), the Anatolian-Eurasian plate boundary is characterised by an intracontinental right-lateral strike-slip transform fault that covers approximately 1500 km in northern Turkey. The 1999 Izmit, Duzce, and 1967 Mudurnu earthquakes, which severely devastated the study region and its environs, are the most major earthquakes in the western branch of the NAFZ in the last 60 years. The North Anatolian Fault Zone (NAFZ), which begins with the Karliova triple junction and stretches approximately 1500 km west, is central to this earthquake activity. The Marmara region is a part of the North Anatolian Fault (NAF), which extends towards northern Turkey.

It is situated near the boundary between the Anatolian Plate and the Eurasian Plate, where the plates interact in a challenging manner [16]. The geology of the Marmara region consists of sedimentary, metamorphic, and igneous rocks. The existence of fault zones, such as the North Anatolian Fault and its branches, involves the region's seismic activity. As a result of its proximity to the Sea of Marmara and the presence of soft sediments in coastal areas, the Marmara region is vulnerable to soil liquefaction during earthquakes, which stimulates seismic hazard.

On the other side, Iraq, located southeast of Turkey, shares a border with Turkey's southeastern area. Iraq is located on the northern section of the Arabian Plate and is limited to the north and east by the Bitlis-Zagros Fold and Thrust Belt, which is formed when the Eurasian and Arabian plates collide, causing increased seismic activity. The rest of the country is primarily located on the Arabian Platform, far from major plate borders. The Dead Sea fault system, a large left-lateral transform fault, forms the western boundary of the Arabian Platform, approximately 250 kilometres from Iraq's westernmost point [2]. However, Iraq recently experienced the effects of earthquake epicentres and has the potential for substantial seismic dangers in the future. The northern section of the country is most vulnerable to high-magnitude earthquakes over the next 50 years [1].

## 3. Methodology

Calculate liquefaction with shear wave velocity depending on soil conditions and the magnitude of the earthquake by measuring three parameters CSR, CRR, and FS. LiquefyPro 5.5 is one of the CivilTech engineering applications established to examine the possibility of liquefaction in seismic conditions. The liquefaction resistance, as measured by seismic testing, was computed using the formula below, The equations below have major factors that are utilised to analyse the potential of liquefaction (PL) in this study. This study identifies LP values based on the categorization of (Appendix 1):

$$FS = \frac{\mathrm{CRR}}{\mathrm{CSR}} \ldots\ldots\ldots 1$$

$$CCR = exp\left\{\frac{[(0.0073.Vs1)^{2.8011} - 2.6168.In(Mw) - 0.0099.1n(\sigma_{vo}) + 0.0028.FC + 0.4809.\Theta^{-1\ (PL)}}{1.946}\right. \ldots\ldots 2$$

$$V_{s1} = V_s\ (\frac{Pa}{\sigma_v})^{0.25} \ldots\ldots\ldots 3$$

$$\mathrm{P_L} = \Theta\left(-\frac{0.0073.\mathrm{Vs1}^{2.8011} - 1946.\mathrm{In(CSR)}2.6168(\mathrm{Mw}) - 0.0099.\mathrm{In}(\sigma_{\mathrm{vo}}) + 0.0028.\mathrm{FC}}{0.4809}\right) \ldots\ldots\ldots 4$$

Where:
Pa: stress equal to 100 kPa
Vs: shear wave velocity
CRR: cyclic resistance ratio
CSR: cyclic stress ratio
FS: factor safety
PL: probability of liquefaction
In general, Vs values in this study are derived from actual field studies rather than empirical correlations.

The engineering properties of the various strata of many geophysical and soil investigation reports for projects in Iraq, and the parameters are evaluated from field and laboratory test results of the available geophysical and geotechnical investigation reports collected from different sources.

## 4. Data collection

Data from this study were collected at the regional level. Data from Turkey show two events: Mw: 7.4 1999 Izmit (PGA: 0.41 g), Mw: 7.0 1967 (max: 0.28 g). Mudurnu [16]. Furthermore, various places in Iraq have alternative earthquake scenarios that have been recorded in various locations across Iraqi land [15]. The peak ground acceleration has been estimated using the information in Fig. 1. The key objective of this research is to apply Random Force (RF) to the prediction of liquefaction using Vs measurements.

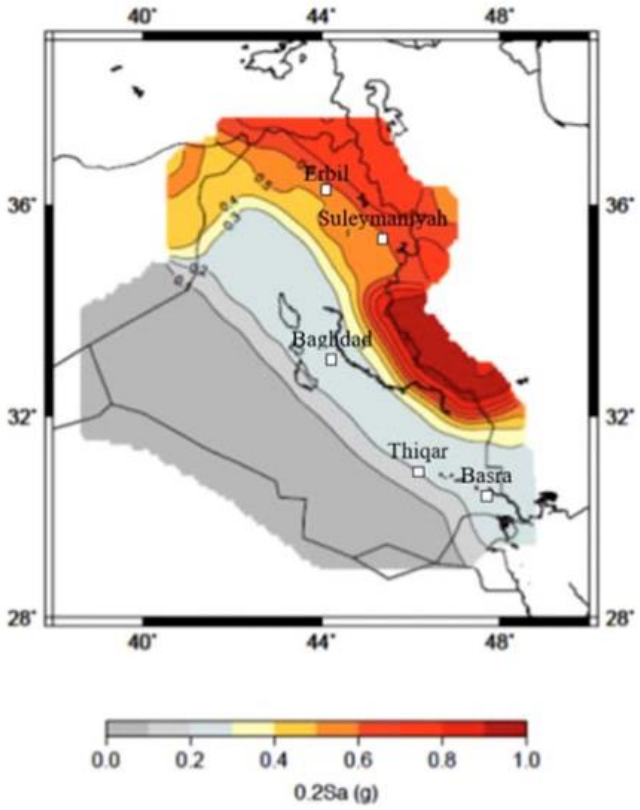


Figure 1 Probabilistic seismic hazard in Iraq with a 2% chance of exceedance in 50 years [1].

## 5. Random forest (RF)

The Random Forest (RF) methodology is an intelligent recognition system based on statistical learning theory [5]. It uses ensemble learning algorithms to create numerous predictors, making it suitable for both classification and regression problems. Random Forest in this research process as classification which is a method of group learning that improves the accuracy and robustness of classification problems. During training, the algorithm generates a large number of decision trees and outputs the class that represents the mode of the categorization classes. Each decision tree in the random forest is built with a subset of the training data and a random selection of features, which adds diversity to the trees and makes the model more resilient and less prone to overfitting.

Given that liquefaction evaluation often yields two outcomes (liquefaction or non-liquefaction) the study adopts a classification tree approach. The goal is to investigate the correlation between the chance of liquefaction and shear wave velocity. The liquefaction classifier is classified as binary (just 1/-1). [20] to distinguish between two categories, such as liquefaction as 1 and non-liquefaction as -1.

## 6. Result and Discussion

The input parameters employed include σ′v, soil type, Fc, Vs, PGA, and M to evaluate the Probability of Liquefaction area of study PL. The data presented in Table (Appendix.1) some areas exhibit no signs of liquefaction, while others demonstrate liquefaction potential. This discovery is reassuring in terms of seismic risk since it suggests that under normal conditions, the soil is less prone to liquefaction-induced damage. However, it is critical to interpret these results with caution, given the differences in liquefaction susceptibility across various locations and soil types.

The research also clearly shows the significance of shear wave velocity (Vs). Higher Vs values often imply firmer soil, which effectively resists liquefaction. Lower Vs values indicate softer, potentially more liquefiable soil. As a result, locations with lower Vs values may be more susceptible to liquefaction, even in the absence of strong seismic activity [14].

Peak ground acceleration (PGA) is an important measure in estimating liquefaction potential since it directly affects the dynamic loading received by the soil during an earthquake. Higher PGA values indicate more ground shaking, which can cause liquefaction in sensitive soils. Thus, even in places with relatively moderate earthquake magnitudes, elevated PGA levels might increase the risk of liquefaction, especially in areas with softer soil [16].

Furthermore, the magnitude of the earthquake (M) significantly influences liquefaction susceptibility. While the overall results show low magnitudes, it is vital to recognise that larger magnitude earthquakes can greatly increase liquefaction potential, particularly in places with susceptible soil conditions [7].

The evaluation of liquefaction by using Randon Forast algorithm RF. The general reliability of this model in predicting liquefaction appears to be good. The evaluation matrix shows that accuracy: is 92.22%, precision is 93.5%, Recall: is 93.5%, and specificity is 90.3% with a high precision, which is a proportion of actual liquefaction cases among all predicted cases. Furthermore, the recall and specificity, which represent the percentage of actual liquefaction and non-liquefaction cases, demonstrate effective prediction of liquefaction based on shear wave velocity, given the high performance metric observed.

Table 1 Statistical analysis of the dataset

| | M | a max(g) | vs (m/s) | LP |
|---|---|---|---|---|
| **count** | 219 | 219 | 219 | 219 |
| **mean** | 6.704762 | 0.347275 | 247.263004 | 0.003663 |
| **std** | 0.831688 | 0.079892 | 142.041713 | 1.00183 |
| **min** | 5 | 0.172 | 102 | -1 |
| **25%** | 6 | 0.26 | 181 | -1 |
| **50%** | 7.4 | 0.41 | 201 | 1 |
| **75%** | 7.4 | 0.41 | 246 | 1 |
| **max** | 7.5 | 0.43 | 1203 | 1 |

## 7. Conclusions

To sum up, our research has yielded significant insights into the evaluation of soil liquefaction potential in Turkey and Iraq through the application of a combination of geotechnical engineering and geophysical studies. It was observed that most of Iraq's regions were less likely to experience liquefaction because of incidents involving low seismic magnitudes and wide divisions from seismic sources; however, some areas were more susceptible because of structural weaknesses in the composition of the soil. This demonstrates how crucial it is to carry out in-depth geotechnical studies in earthquake-prone areas to guarantee the resilience of infrastructure and community safety.

However, Turkey displayed evidence of liquefaction due to its extensive high-magnitude earthquake epicentres, underscoring the necessity of adequate risk mitigation measures. The studies we conducted also revealed the value of

machine learning, specifically the Random Forest algorithm, in predicting liquefaction potential using shear wave velocity. The high accuracy, precision, recall, and specificity seen in our evaluation metrics suggest that this model is reliable in forecasting liquefaction events. These findings emphasise the importance of adding advanced analytical tools into liquefaction assessments to increase prediction precision and catastrophe management.

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**Appendix 1:** Dataset used to calculate LP.

| M | a max(g) | vs (m/s) | FC(%) | $\sigma v'$ (kPa) | LP (actual) |
|---|---|---|---|---|---|
| 7.4 | 0.41 | 209 | 4 | 72 | 1 |
| 7.4 | 0.41 | 201 | 22 | 85 | -1 |
| 7.4 | 0.41 | 194 | 47 | 97 | -1 |
| 7.4 | 0.41 | 170 | 58 | 70 | -1 |
| 7.4 | 0.41 | 190 | 35 | 124 | -1 |
| 7.4 | 0.41 | 185 | 35 | 137 | -1 |
| 7.4 | 0.41 | 162 | 64 | 78 | -1 |
| 7.4 | 0.41 | 157 | 64 | 142 | -1 |
| 7.4 | 0.41 | 153 | 65 | 155 | -1 |
| 7.4 | 0.41 | 207 | 70 | 57 | 1 |
| 7.4 | 0.41 | 198 | 61 | 68 | -1 |
| 7.4 | 0.41 | 191 | 69 | 79 | -1 |
| 7.4 | 0.41 | 185 | 70 | 90 | -1 |
| 7.4 | 0.41 | 213 | 68 | 101 | 1 |
| 7.4 | 0.41 | 208 | 68 | 112 | -1 |
| 7.4 | 0.41 | 220 | 70 | 123 | 1 |
| 7.4 | 0.41 | 216 | 69 | 134 | 1 |
| 7.4 | 0.41 | 206 | 14 | 39 | -1 |
| 7.4 | 0.41 | 194 | 6 | 49 | -1 |
| 7.4 | 0.41 | 221 | 6 | 59 | 1 |
| 7.4 | 0.41 | 212 | 10 | 70 | -1 |
| 7.4 | 0.41 | 246 | 16 | 91 | 1 |
| 7.4 | 0.41 | 239 | 21 | 101 | 1 |
| 7.4 | 0.41 | 233 | 22 | 112 | 1 |
| 7.4 | 0.41 | 175 | 26 | 122 | -1 |
| 7.4 | 0.41 | 172 | 26 | 132 | -1 |
| 7.4 | 0.41 | 168 | 28 | 143 | -1 |
| 7.4 | 0.41 | 165 | 24 | 153 | -1 |
| 7.4 | 0.41 | 242 | 79 | 63 | 1 |
| 7.4 | 0.41 | 242 | 65 | 127 | 1 |
| 7.4 | 0.41 | 157 | 71 | 60 | -1 |
| 7.4 | 0.41 | 188 | 76 | 80 | -1 |
| 7.4 | 0.41 | 151 | 68 | 90 | -1 |
| 7.4 | 0.41 | 147 | 68 | 100 | -1 |
| 7.4 | 0.41 | 201 | 70 | 58 | -1 |
| 7.4 | 0.41 | 195 | 61 | 69 | -1 |
| 7.4 | 0.41 | 188 | 69 | 81 | -1 |
| 7.4 | 0.41 | 182 | 70 | 92 | -1 |
| 7.4 | 0.41 | 190 | 68 | 103 | -1 |
| 7.4 | 0.41 | 185 | 68 | 114 | -1 |
| 7.4 | 0.41 | 180 | 70 | 126 | -1 |
| 7.4 | 0.41 | 189 | 69 | 137 | -1 |
| 7.4 | 0.41 | 194 | 71 | 65 | -1 |
| 7.4 | 0.41 | 187 | 68 | 74 | -1 |
| 7.4 | 0.41 | 204 | 71 | 67 | -1 |
| 7.4 | 0.41 | 195 | 27 | 79 | -1 |
| 7.4 | 0.41 | 187 | 63 | 141 | -1 |
| 7.4 | 0.41 | 183 | 71 | 153 | -1 |
| 7.4 | 0.41 | 180 | 70 | 165 | -1 |
| 7.4 | 0.41 | 180 | 30 | 55 | -1 |
| 7.4 | 0.41 | 211 | 30 | 66 | -1 |
| 7.4 | 0.41 | 202 | 24 | 78 | -1 |
| 7.4 | 0.41 | 228 | 32 | 90 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| 7.4 | 0.41 | 221 | 32 | 101 | 1 |
| 7.4 | 0.41 | 215 | 33 | 113 | 1 |
| 7.4 | 0.41 | 210 | 32 | 125 | -1 |
| 7.4 | 0.41 | 205 | 23 | 136 | -1 |
| 7.4 | 0.41 | 201 | 32 | 148 | -1 |
| 7.4 | 0.41 | 168 | 85 | 69 | -1 |
| 7.4 | 0.41 | 161 | 84 | 81 | -1 |
| 7.4 | 0.41 | 206 | 85 | 73 | 1 |
| 7.4 | 0.41 | 198 | 4 | 85 | -1 |
| 7.4 | 0.41 | 191 | 2 | 98 | -1 |
| 7.4 | 0.41 | 204 | 3 | 111 | -1 |
| 7.4 | 0.41 | 198 | 2 | 123 | -1 |
| 7.4 | 0.41 | 193 | 3 | 136 | -1 |
| 7.4 | 0.41 | 189 | 2 | 149 | -1 |
| 7.4 | 0.41 | 160 | 2 | 162 | -1 |
| 7.4 | 0.41 | 157 | 3 | 174 | -1 |
| 7.4 | 0.41 | 154 | 3 | 187 | -1 |
| 7.4 | 0.41 | 189 | 85 | 66 | -1 |
| 7.4 | 0.41 | 180 | 82 | 80 | -1 |
| 7.4 | 0.41 | 213 | 84 | 93 | 1 |
| 7.4 | 0.41 | 199 | 22 | 121 | -1 |
| 7.4 | 0.41 | 213 | 88 | 149 | 1 |
| 7.4 | 0.41 | 208 | 83 | 162 | 1 |
| 7.4 | 0.41 | 124 | 19 | 114 | -1 |
| 7.4 | 0.41 | 140 | 92 | 73 | -1 |
| 7.4 | 0.41 | 135 | 92 | 86 | -1 |
| 7.4 | 0.41 | 199 | 82 | 98 | 1 |
| 7.4 | 0.41 | 193 | 88 | 110 | -1 |
| 7.4 | 0.41 | 188 | 16 | 123 | -1 |
| 7.4 | 0.41 | 184 | 15 | 135 | -1 |
| 7.4 | 0.41 | 150 | 15 | 148 | -1 |
| 7.4 | 0.41 | 147 | 13 | 161 | -1 |
| 7.4 | 0.41 | 145 | 14 | 174 | -1 |
| 7.4 | 0.41 | 142 | 13 | 186 | -1 |
| 7.4 | 0.41 | 137 | 9.2 | 46 | -1 |
| 7.4 | 0.41 | 138 | 8 | 85 | -1 |
| 7.4 | 0.41 | 236 | 10 | 98 | 1 |
| 7.4 | 0.41 | 229 | 15 | 111 | 1 |
| 7.4 | 0.41 | 223 | 53 | 124 | 1 |
| 7.4 | 0.41 | 217 | 54 | 137 | 1 |
| 7.4 | 0.41 | 243 | 83 | 41 | 1 |
| 7.4 | 0.41 | 210 | 83 | 52 | 1 |
| 7.4 | 0.41 | 200 | 96 | 63 | -1 |
| 7.4 | 0.41 | 192 | 96 | 74 | -1 |
| 7.4 | 0.41 | 136 | 96 | 85 | -1 |
| 7.4 | 0.41 | 132 | 96 | 95 | -1 |
| 7.4 | 0.41 | 128 | 96 | 106 | -1 |
| 7.4 | 0.41 | 170 | 34 | 74 | -1 |
| 7.4 | 0.41 | 213 | 37 | 62 | 1 |
| 7.4 | 0.41 | 199 | 40 | 73 | -1 |
| 7.4 | 0.41 | 211 | 34 | 105 | -1 |
| 7.4 | 0.41 | 206 | 34 | 116 | -1 |
| 7.4 | 0.41 | 180 | 51 | 59 | -1 |
| 7.4 | 0.41 | 171 | 52 | 73 | -1 |
| 7.4 | 0.41 | 152 | 55 | 99 | -1 |
| 7.4 | 0.41 | 148 | 70 | 113 | -1 |
| 7.4 | 0.41 | 195 | 71 | 126 | -1 |
| 7.4 | 0.41 | 237 | 3 | 69 | 1 |
| 7.4 | 0.41 | 227 | 15 | 81 | 1 |
| 7.4 | 0.41 | 220 | 13 | 94 | 1 |
| 7.4 | 0.41 | 193 | 12 | 106 | -1 |
| 7.4 | 0.41 | 188 | 9 | 118 | -1 |
| 7.4 | 0.41 | 176 | 23 | 82 | -1 |
| 7.4 | 0.41 | 174 | 15 | 117 | -1 |
| 7.4 | 0.41 | 184 | 27 | 130 | -1 |
| 7.4 | 0.41 | 179 | 21 | 142 | -1 |

| | | | | | |
|---|---|---|---|---|---|
| 7.4 | 0.41 | 176 | 16 | 155 | -1 |
| 7.4 | 0.41 | 194 | 93 | 51 | 1 |
| 7.4 | 0.41 | 197 | 93 | 64 | -1 |
| 7.4 | 0.41 | 188 | 93 | 77 | -1 |
| 7.4 | 0.41 | 181 | 93 | 90 | -1 |
| 7.4 | 0.41 | 211 | 17 | 103 | -1 |
| 7.4 | 0.41 | 204 | 16 | 116 | -1 |
| 7.4 | 0.41 | 199 | 19 | 129 | -1 |
| 7.4 | 0.41 | 212 | 93 | 142 | 1 |
| 7.4 | 0.41 | 207 | 93 | 155 | 1 |
| 7.4 | 0.41 | 203 | 93 | 168 | -1 |
| 7.4 | 0.41 | 199 | 93 | 181 | -1 |
| 7.4 | 0.41 | 196 | 93 | 194 | -1 |
| 7.4 | 0.41 | 179 | 28 | 67 | -1 |
| 7.4 | 0.41 | 197 | 24 | 95 | -1 |
| 7.4 | 0.41 | 207 | 8 | 135 | -1 |
| 7.4 | 0.41 | 184 | 43 | 84 | -1 |
| 7.5 | 0.34 | 173 | 9 | 62.1 | -1 |
| 7.5 | 0.34 | 176 | 11 | 77 | -1 |
| 7.5 | 0.34 | 181 | 14 | 92.3 | -1 |
| 7.5 | 0.34 | 191 | 13 | 107.6 | -1 |
| 7.5 | 0.34 | 191 | 12 | 122.9 | -1 |
| 7.5 | 0.34 | 194 | 14 | 138.8 | -1 |
| 7.5 | 0.34 | 200 | 15 | 154.7 | -1 |
| 6.5 | 0.23 | 175 | 4 | 62.4 | 1 |
| 6.5 | 0.23 | 174 | 8 | 77.3 | -1 |
| 6.5 | 0.23 | 179 | 7 | 92.5 | -1 |
| 6.5 | 0.23 | 180 | 4 | 107.6 | -1 |
| 6.5 | 0.23 | 191 | 4 | 122.8 | -1 |
| 6.5 | 0.23 | 193 | 4 | 138.7 | -1 |
| 6.5 | 0.23 | 201 | 5 | 154.6 | -1 |
| 7.5 | 0.3 | 175 | 5 | 140.6 | -1 |
| 7.5 | 0.3 | 196 | 8 | 154.4 | -1 |
| 7.5 | 0.3 | 224 | 12 | 168.3 | -1 |
| 7.5 | 0.3 | 238 | 10 | 182.5 | 1 |
| 7.5 | 0.3 | 240 | 7 | 196.7 | 1 |
| 7.5 | 0.3 | 241 | 6 | 210.9 | 1 |
| 6.5 | 0.24 | 175 | 6 | 141.4 | -1 |
| 6.5 | 0.24 | 192 | 8 | 155.3 | -1 |
| 6.5 | 0.24 | 223 | 11 | 169.2 | -1 |
| 6.5 | 0.24 | 221 | 10 | 183 | -1 |
| 6.5 | 0.24 | 231 | 7 | 197.1 | -1 |
| 6.5 | 0.24 | 242 | 6 | 211.4 | 1 |
| 6.3 | 0.4 | 302 | 45 | 35.6 | 1 |
| 6.3 | 0.4 | 468 | 10 | 109.8 | 1 |
| 6.3 | 0.4 | 832 | 8 | 58.8 | 1 |
| 6.3 | 0.4 | 274 | 50 | 52.2 | 1 |
| 6.3 | 0.4 | 354 | 45 | 121.2 | 1 |
| 6.3 | 0.4 | 260 | 10 | 28.2 | 1 |
| 6.3 | 0.4 | 296 | 30 | 74.6 | 1 |
| 6.3 | 0.4 | 462 | 33 | 159 | 1 |
| 6.1 | 0.43 | 262 | 0 | 50.2 | 1 |
| 6.1 | 0.43 | 576 | 0 | 201.7 | 1 |
| 6.1 | 0.43 | 384 | 0 | 68.8 | 1 |
| 6.1 | 0.43 | 233 | 0 | 68.8 | 1 |
| 6.3 | 0.26 | 219 | 38 | 49.4 | 1 |
| 6.3 | 0.26 | 301 | 10 | 69 | 1 |
| 6.3 | 0.26 | 733 | 10 | 206 | 1 |
| 6.3 | 0.26 | 145 | 20 | 29 | 1 |
| 6.3 | 0.26 | 212 | 60 | 59 | 1 |
| 6.3 | 0.26 | 323 | 60 | 184.2 | 1 |
| 6.3 | 0.26 | 225 | 18 | 32.8 | 1 |
| 6.3 | 0.26 | 321 | 60 | 173.2 | 1 |
| 6.3 | 0.26 | 476 | 0 | 284.5 | 1 |
| 6.3 | 0.26 | 304 | 66 | 121.8 | 1 |
| 6.3 | 0.26 | 312 | 65 | 112.8 | 1 |

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|---|---|---|---|---|---|
| 6.2 | 0.43 | 459 | 66 | 147.8 | 1 |
| 6.2 | 0.43 | 319 | 22 | 73.55 | 1 |
| 6.2 | 0.43 | 348 | 5 | 163.55 | 1 |
| 5.2 | 0.36 | 303 | 10 | 51 | 1 |
| 5.2 | 0.36 | 362 | 10 | 76.2 | 1 |
| 5.2 | 0.36 | 292 | 10 | 26.8 | 1 |
| 5.2 | 0.36 | 346 | 15 | 57.7 | 1 |
| 6 | 0.3 | 606 | 10 | 134.3 | 1 |
| 6 | 0.3 | 451 | 6 | 44.2 | 1 |
| 6 | 0.3 | 701 | 5 | 117.8 | 1 |
| 6 | 0.3 | 186 | 28 | 98.8 | 1 |
| 6 | 0.3 | 258 | 9 | 160 | 1 |
| 6 | 0.3 | 265 | 60 | 92.2 | 1 |
| 6 | 0.3 | 395 | 30 | 157.3 | 1 |
| 6 | 0.3 | 153 | 30 | 98.8 | -1 |
| 6 | 0.3 | 215 | 25 | 172.4 | 1 |
| 6 | 0.3 | 298 | 50 | 108.8 | 1 |
| 6 | 0.3 | 428 | 45 | 160.8 | 1 |
| 6 | 0.3 | 507 | 10 | 413.25 | 1 |
| 6 | 0.3 | 240 | 25 | 110.8 | 1 |
| 6 | 0.3 | 430 | 10 | 153.8 | 1 |
| 6 | 0.3 | 140 | 20 | 19 | 1 |
| 6 | 0.3 | 219 | 50 | 146.12 | 1 |
| 6 | 0.3 | 408 | 10 | 227.67 | 1 |
| 6 | 0.3 | 189 | 30 | 69.8 | 1 |
| 6 | 0.3 | 248 | 60 | 125 | 1 |
| 6 | 0.3 | 225 | 10 | 271.4 | 1 |
| 6 | 0.3 | 165 | 60 | 84.8 | -1 |
| 6 | 0.3 | 279 | 10 | 126.2 | 1 |
| 6 | 0.3 | 260 | 50 | 67.1 | 1 |
| 6 | 0.31 | 369 | 10 | 155.1 | 1 |
| 6 | 0.31 | 111 | 30 | 22.56 | -1 |
| 6 | 0.172 | 183 | 20 | 134.88 | 1 |
| 6 | 0.172 | 372 | 45 | 122.8 | 1 |
| 6 | 0.172 | 398 | 45 | 167.3 | 1 |
| 5 | 0.2 | 817.8 | 20 | 54.3 | 1 |
| 5 | 0.2 | 1164 | 10 | 117.3 | 1 |
| 5 | 0.2 | 1203 | 5 | 240.8 | 1 |
| 5 | 0.2 | 257 | 50 | 62.8 | 1 |
| 5 | 0.2 | 379 | 14 | 104.8 | 1 |
| 5 | 0.2 | 198 | 50 | 58.3 | 1 |
| 5 | 0.2 | 265 | 20 | 92.7 | 1 |
| 5 | 0.2 | 497 | 15 | 246 | 1 |
| 5 | 0.2 | 417 | 35 | 186.2 | 1 |
| 5 | 0.2 | 312 | 30 | 101.15 | 1 |
| 5 | 0.2 | 289 | 0 | 142.85 | 1 |
| 5 | 0.2 | 284 | 15 | 50.3 | 1 |
| 5 | 0.2 | 550 | 15 | 37.7 | 1 |
| 6 | 0.37 | 563 | 18 | 199.1 | 1 |
| 6 | 0.37 | 618 | 3 | 86.8 | 1 |
| 6 | 0.37 | 268 | 15 | 19.1 | 1 |
| 6 | 0.37 | 557 | 5 | 58.2 | 1 |
| 6 | 0.37 | 659 | 23 | 148.8 | 1 |
| 6 | 0.37 | 111 | 50 | 66.2 | -1 |
| 6 | 0.37 | 152 | 10 | 151.4 | -1 |
| 6 | 0.37 | 211 | 50 | 327.2 | 1 |
| 6 | 0.37 | 131 | 50 | 50.8 | -1 |
| 6 | 0.37 | 250 | 50 | 79.9 | 1 |
| 6 | 0.37 | 420 | 50 | 268.9 | 1 |
| 5.5 | 0.2 | 179 | 50 | 98.9 | 1 |
| 5.5 | 0.2 | 380 | 50 | 198.8 | 1 |
| 5.5 | 0.2 | 176 | 50 | 53.45 | 1 |
| 5.5 | 0.2 | 200 | 10 | 53.25 | 1 |
| 5.5 | 0.2 | 250 | 60 | 145.8 | 1 |
| 5.5 | 0.2 | 225 | 40 | 58.8 | 1 |
| 5.5 | 0.2 | 243 | 15 | 69.7 | 1 |

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|---|---|---|---|---|---|
| 5.5 | 0.2 | 333 | 60 | 205.7 | 1 |
| 5.5 | 0.2 | 188 | 60 | 25.1 | 1 |
| 5.5 | 0.2 | 185 | 10 | 30.2 | 1 |
| 5.5 | 0.2 | 200 | 60 | 136.2 | 1 |
| 5.5 | 0.2 | 185 | 30 | 84.2 | 1 |
| 5.5 | 0.2 | 321 | 50 | 121.8 | 1 |
| 5.5 | 0.25 | 110 | 60 | 126.2 | -1 |
| 5.5 | 0.25 | 145 | 15 | 148.2 | 1 |
| 5.5 | 0.25 | 166 | 60 | 393.2 | 1 |
| 5.5 | 0.25 | 200 | 60 | 46.88 | 1 |
| 5.5 | 0.25 | 240 | 60 | 107.66 | 1 |
| 5.5 | 0.25 | 329 | 15 | 41.3 | 1 |
| 5.5 | 0.25 | 627 | 10 | 105 | 1 |
| 5.5 | 0.25 | 230 | 3 | 36.8 | 1 |
| 5.5 | 0.25 | 365 | 15 | 129.96 | 1 |
| 5.5 | 0.25 | 166 | 50 | 77.6 | 1 |
| 5.5 | 0.25 | 194 | 10 | 160.4 | 1 |
| 5.5 | 0.25 | 117 | 50 | 69.2 | -1 |
| 5.5 | 0.25 | 198 | 50 | 135.8 | 1 |
| 5.5 | 0.25 | 138 | 60 | 95.5 | -1 |
| 5.5 | 0.25 | 103 | 15 | 124.99 | -1 |
| 5.5 | 0.25 | 102 | 50 | 329.13 | -1 |