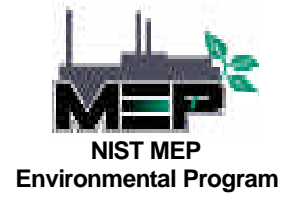


Soil Stabilization For Irrigation Canal Lining



SOIL STABILIZATION FOR IRRIGATION CANAL LINING

FINAL REPORT

PREPARED FOR:

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Report No. IBP-97-2

ACKNOWLEDGMENTS

CWC is a nonprofit organization providing recycling market development services to both businesses and governments, including tools and technologies to help manufacturers use recycled materials. CWC is the managing partner of the Recycling Technology Assistance Partnership (ReTAP), an affiliate of the national Manufacturing Extension Partnership (MEP) -- a program of the US Commerce Department's National Institute of Standards and Technology. The MEP is a growing nationwide network of extension services to help smaller US manufacturers improve their performance and become more competitive. ReTAP is also sponsored by the US Environmental Protection Agency.

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1.0 BACKGROUND

Irrigation canals in Washington State suffer tremendous water losses each year. A substantial percentage of these losses can be attributed to the failure of canal liners. Not only does this represent a considerable financial cost, but canal leakage on slopes may cause considerable hazard to humans if slope failure should occur. Lining the canals with concrete or plastic film can reduce water loss or, as this report describes, the soil may be stabilized with additives.

2.0 INTRODUCTION

The Roza Irrigation District (Washington State) expressed interest in soil stabilization as a repair method for the Terrace Heights Irrigation Canal.

Lime and bentonite are two materials that are used for soil stabilization. However, for this project, tests were conducted using a product called Econolime™ (a by-product of lime manufacturing consisting of calcium carbonate, hydrated lime and silica) as a soil stabilizer. The purpose of this limited study was to determine the reactivity of Econolime™ blends with soil samples taken adjacent to the Terrace Heights Irrigation Canal.

Wedge Engineering and Soils 2001 were retained by CWC to evaluate the reactivity of Econolime™ with the soil samples taken near the Terrace Heights Irrigation Canal. The sampling was performed by Wedge Engineering, with assistance from Soils 2001 (Yakima, WA) and Continental Lime (Tacoma, WA).

3.0 SOIL TYPES

The soil samples tested were obtained from a single test pit along the slope of the Terrace Heights Irrigation Canal. The samples were obtained from just below the topsoil to a depth of 12 to 14 inches. Material containing organics such as plant matter or rootlets was discarded. Each sample was visually classified and sealed in buckets.

The upper layer was approximately six inches thick and consisted of damp, soft, reddish-tan silt. Immediately below this layer was a damp, blocky, hard, tan silt. It was noted that the upper layer appeared to be the weathered zone of the lower silt layer.

4.0 TESTING PROGRAM

At the laboratory, subsamples of the two soil horizons were immediately taken to determine the characteristics of the soil. Characterization tests were performed and included natural water content, soil pH, Atterberg Limits, and grain size distribution. Table 1 summarizes the soil typing. A summary of the characterization tests can also be found in Appendix A, Figure O1 E, Untreated Soil Characteristics (USCS). The laboratory results of the characterization tests are located in Appendix B, Soil Characterization Results.

TABLE 1 SOIL TYPE

TEST PIT	DESCRIPTION	USCS	SOIL PH	LIQUID LIMIT	PLASTICITY INDEX	NATURAL WATER CONTENT
TP 1	Weathered SILT	ML	8.09	42.7	10.3	31.5%
TP 1	SILT	ML	8.03	46.2	5.8	25.7%

5.0 ADMIXTURE TYPE

The original design program called for testing with the two Econolime™ mixes. Econolime™ generally has a 20% to 30% moisture content; some moisture is absorbed during outdoor, uncovered storage. A small amount of lime and cationic starch was also added to some of the samples.

Wedge Engineering expanded the original design program to include an additional admixture, Dical, which is a by-product of magnesium manufacture. Its use allowed for the comparison of Econolime™ with another by-product. Dical consists primarily of dicalcium silicate and aluminum silicate, both common constituents of cement. The material has been used to treat

similar soils and is available in different forms, depending upon its application. For this evaluation, hydrated and re-hydrated Dical were used.

The following mix designs were tested (all concentrations were by dry weight of soil):

- 20% Econolime™ + 4% Quick Lime + 1% Cationic Starch;
- 10% Econolime™ Slurry + 4% Quick Lime + 1% Cationic Starch;
- 20% Econolime™ + 4% Quick Lime;
- 20% Rehydrated Dical; and
- 20% Hydrated Dical

6.0 ADMIXTURE DESIGN

The admixture design was performed on a composite sample of the weathered and unweathered silt. Appendix A, Figure 04E, Initial Mix Design Summary, shows the results of the compressive strength testing with the admixture blends for the Terrace Heights Irrigation Canal.

Econolime™ with quicklime and cationic starch was selected for the final testing sequence. The final mix was compacted into test cylinders, allowed to cure for seven days in closed containers at 100°F, and tested in compression. Samples were also mixed and compacted for durability testing by the vacuum saturation method. This testing was performed after the sample cured for seven days and was intended to provide performance data on the cured material after accelerated weathering.

The vacuum saturation method prescribed by ASTM C 593 imitated an accelerated weathering test, which involved up to ten freeze-thaw and wet-dry cycles. The final mix design had to produce a minimum durability compression strength of 100 psi to allow the stabilized soil to survive its first winter without suffering unrecoverable damage. During the winter, the curing process essentially stops. The lowest strength of the stabilized soil occurs at that time, after

which the material continues to gain strength during subsequent summers. A summary of compressive strength and durability strengths can be found in Appendices A and D.

The permeability of the treated and untreated soil was also tested. The low permeability of the material necessitated the use of a high-pressure permeameter; both tested samples were remolded. The results of the permeability testing are given in Appendix D, Figures P 01 and P 02.

7.0 RESULTS AND CONCLUSIONS

The soil adjacent to the Terrace Heights Irrigation Canal reacted well with the Econolime™ blends. With the exception of the slurry mix, the compressive and durability strengths obtained from the Econolime™ blends were good.

The use of slurries with fine-grained soils is typically not recommended due to soil sensitivity to moisture content during construction. Since the active ingredient in Econolime™ is lime, this admixture would be especially beneficial in this application. Lime tends to be slightly expansive as opposed to cement, which may shrink during curing.

The hydraulic conductivity of both the untreated and treated soil was quite low (10^{-8} and 10^{-6} cm/s, respectively). While the untreated soil had lower hydraulic conductivity, the majority of water moving through silts and clay occurs along fractures and cracks in the soil mass. The blocky nature of the unweathered silt confirmed the presence of these fractures. Thus, the hydraulic conductivity of the silt below the irrigation canal is probably much higher than the laboratory sample tested.

The hydraulic conductivity of the treated sample was similar to that of intact loess silt or glacial till, both relatively impermeable materials. Since the tests were performed when the specimen was fresh and the lime mobile, the permeability is expected to reduce with time.

The intent of this project was to ascertain the feasibility of stabilizing the canal using by-product admixtures. As shown by the test results, the stabilization of the canal using Econolime™ is quite feasible. A full design, during which the entire length of the canal is sampled and evaluated, would be required prior to construction.

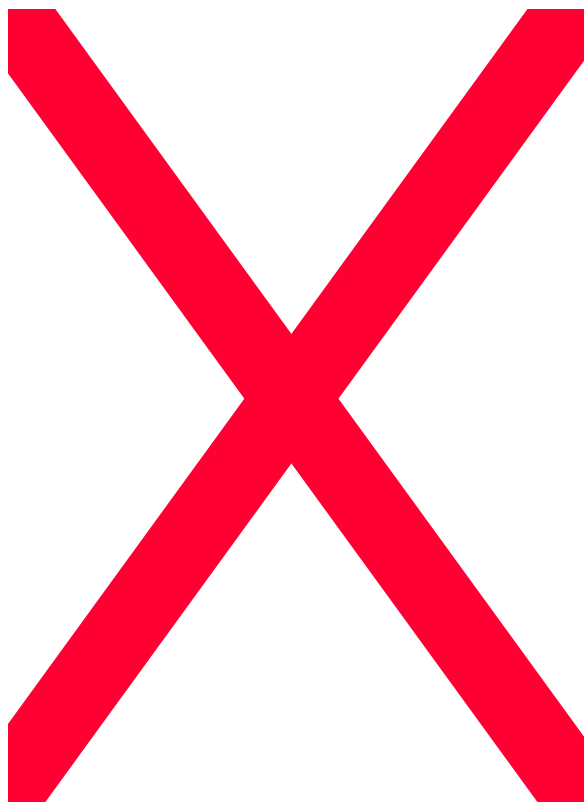
The analyses, conclusions, and recommendations contained in this report are based on the conditions as they existed at the time of investigation and further assume that the explorations are representative of the subsurface conditions throughout the project. If different conditions are observed during construction, Wedge Engineering should be promptly notified for review and reconsideration of our recommendations.

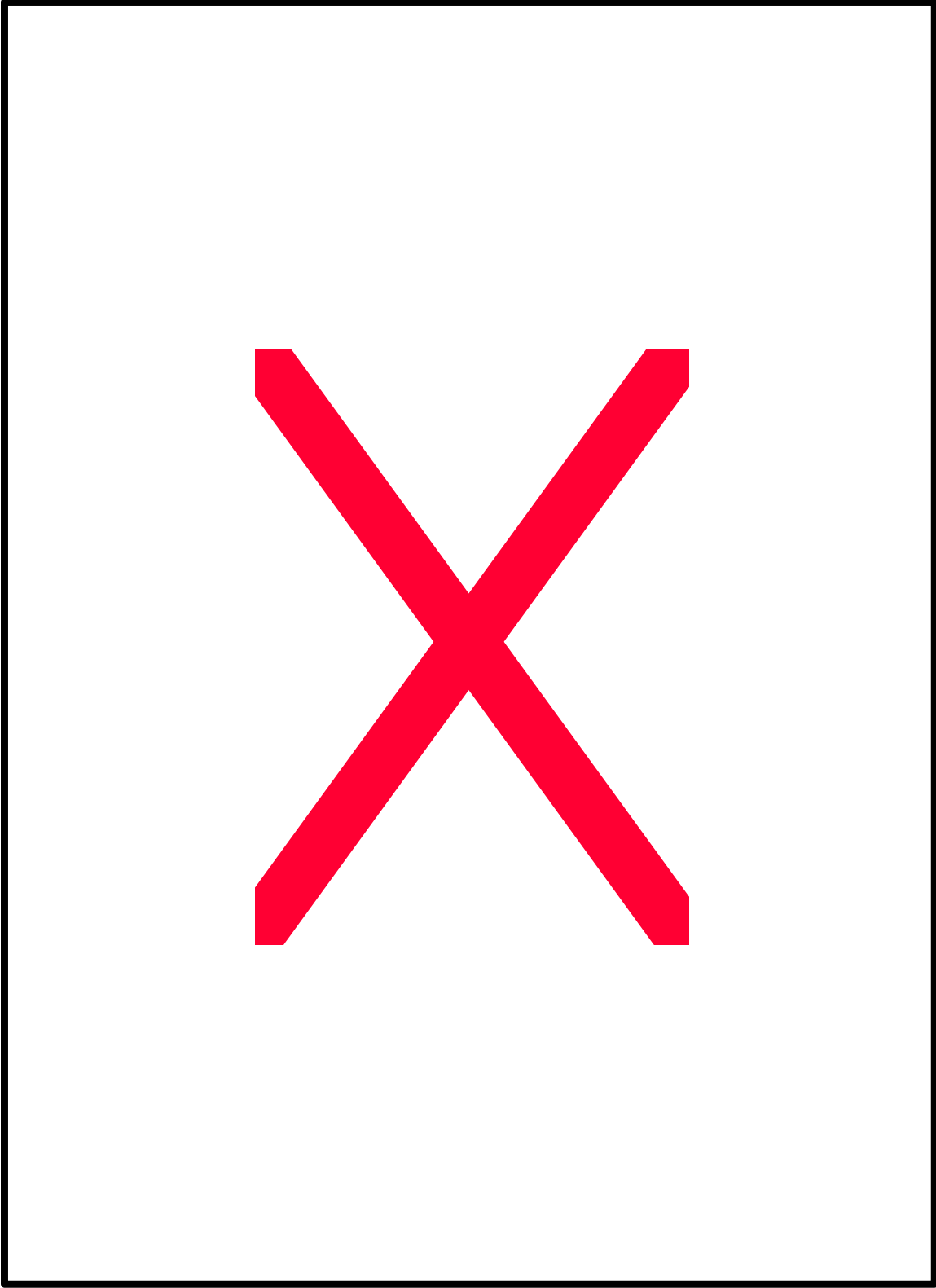
Wedge Engineering has reported findings for this study. Applications of this soil stabilization in other locations, with other soils, weather conditions, etc., may produce significantly different results. Engineers experienced in soil stabilization should be involved in any further studies or applications of this nature, especially during placement, mixing, and compaction of the base. Soil conditions are known to vary and only an engineer experienced in the field of soil stabilization can provide the judgment necessary to ensure a successful project.

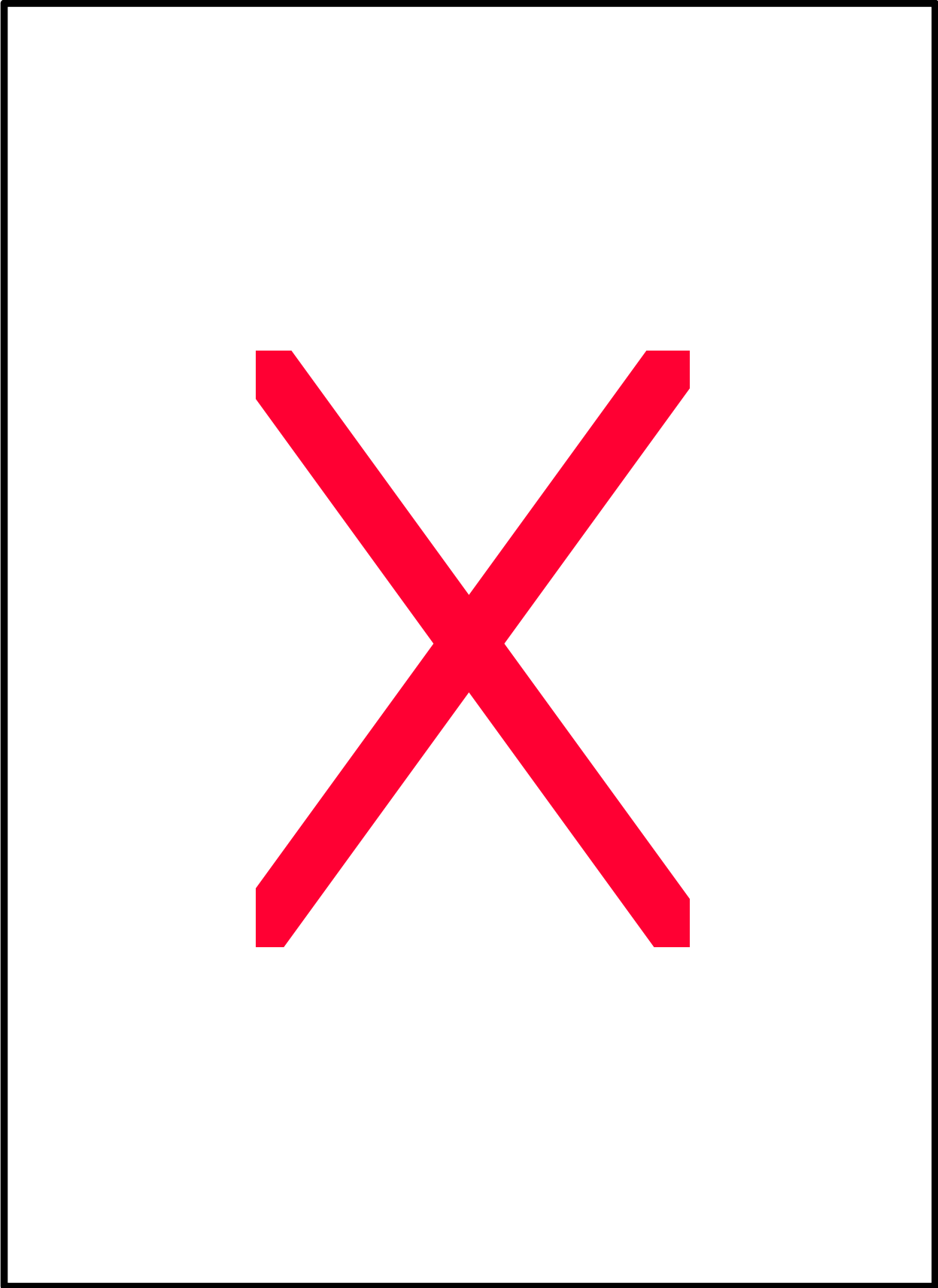
Our investigation was performed using the degree of care and skill ordinarily exercised, under similar circumstances, by reputable soil engineers and geologists practicing in this or similar localities. No other warranty, expressed or implied, is made as to the conclusions and professional advice included in this report.

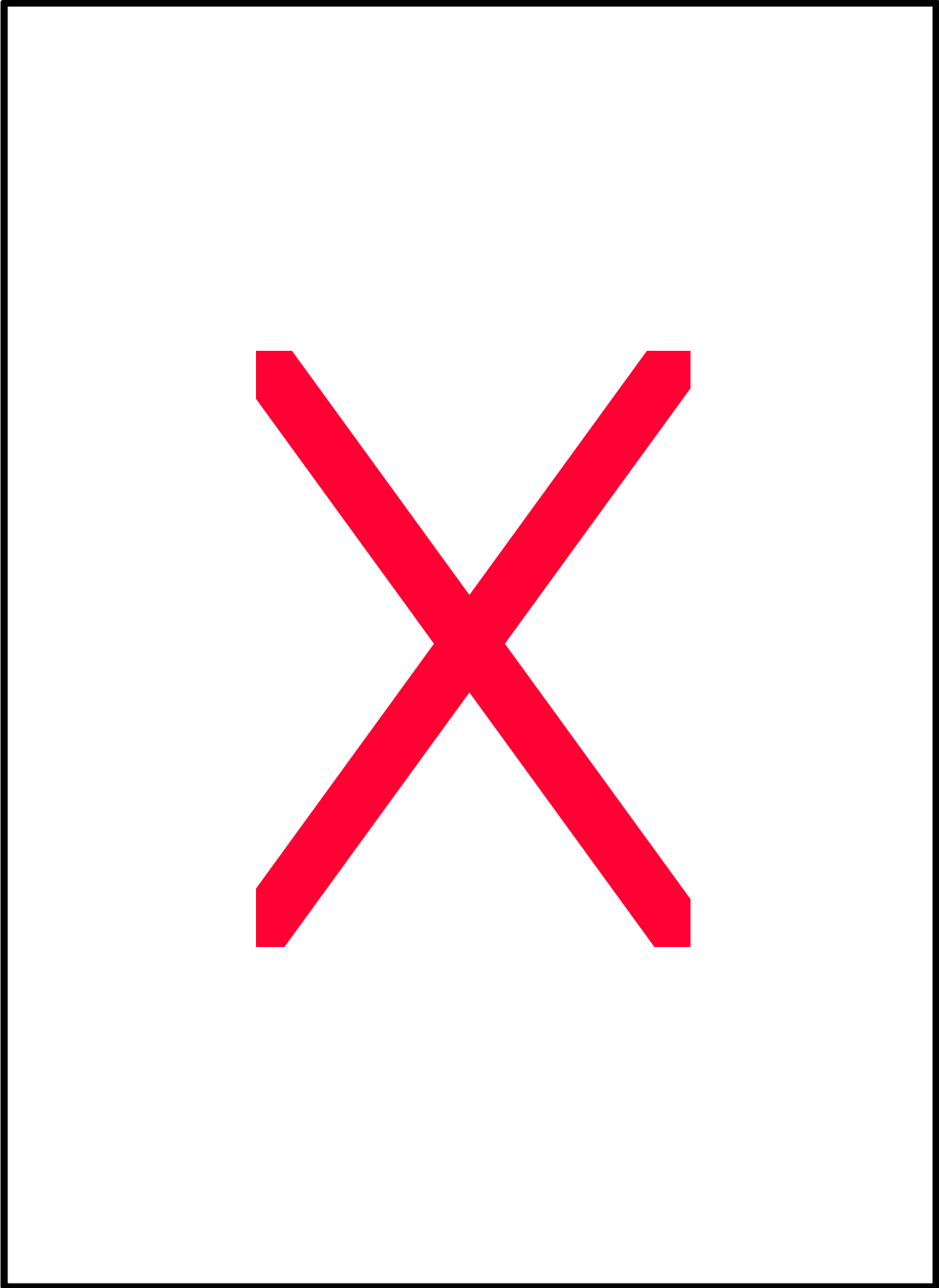
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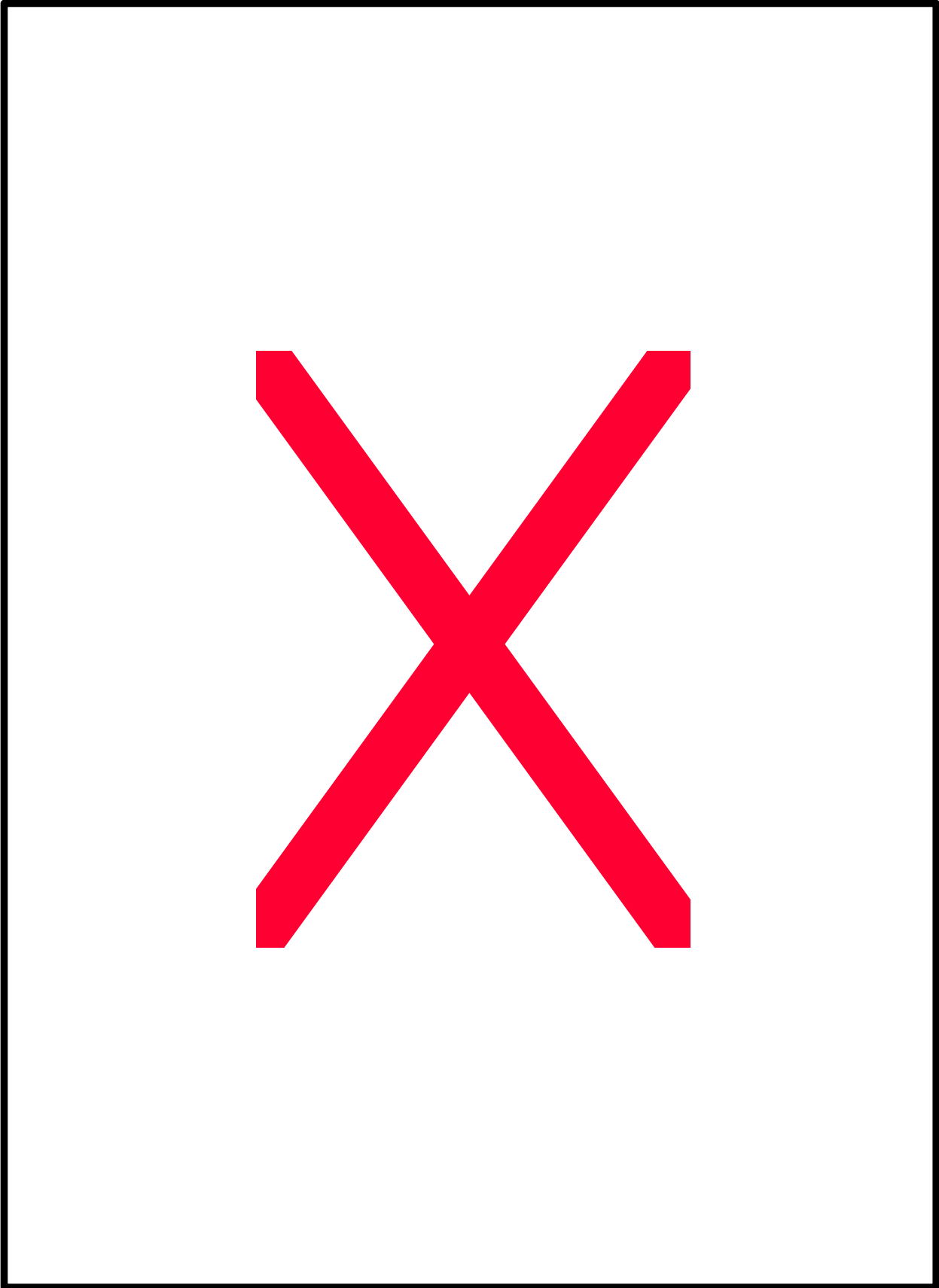
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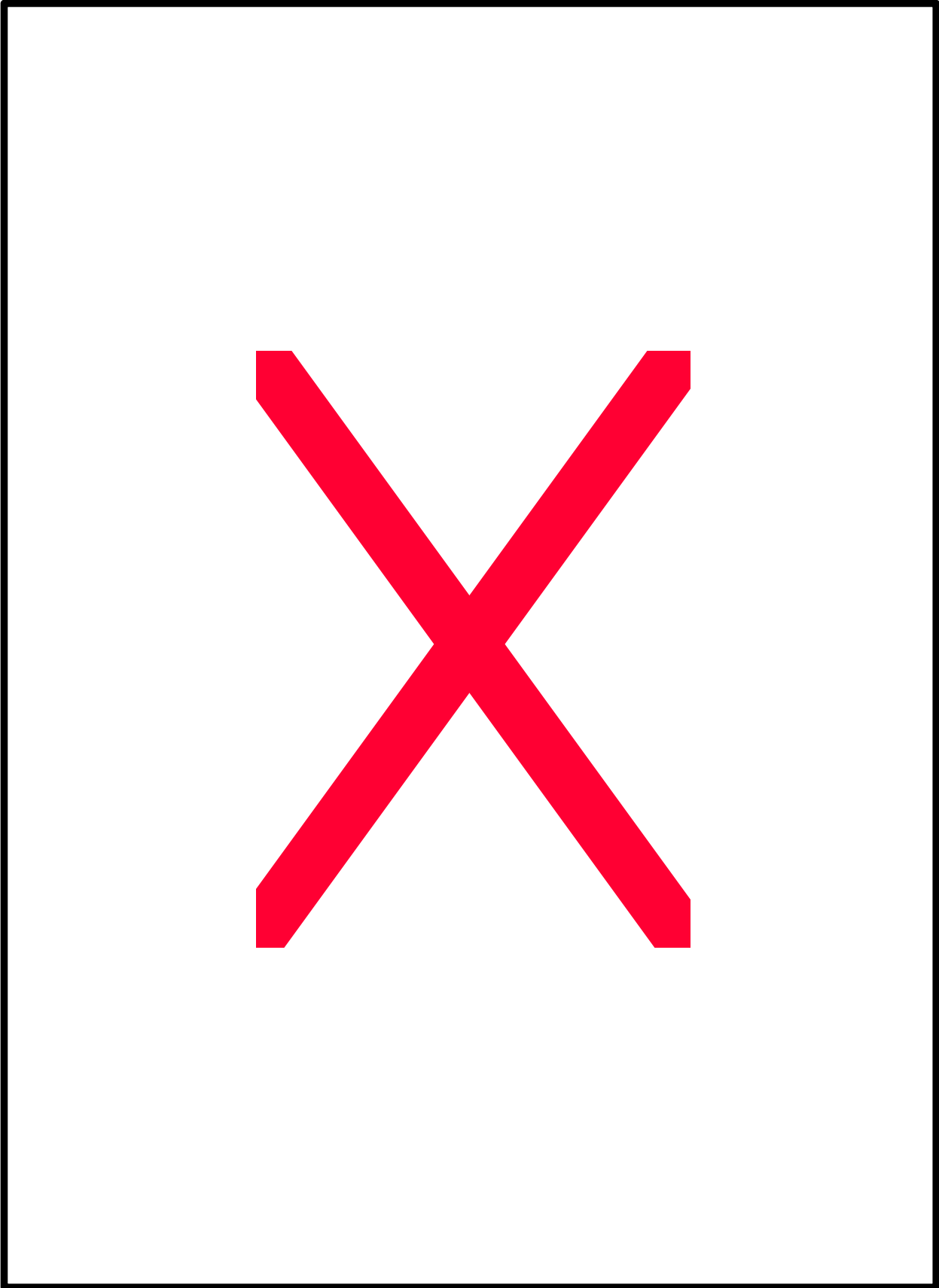






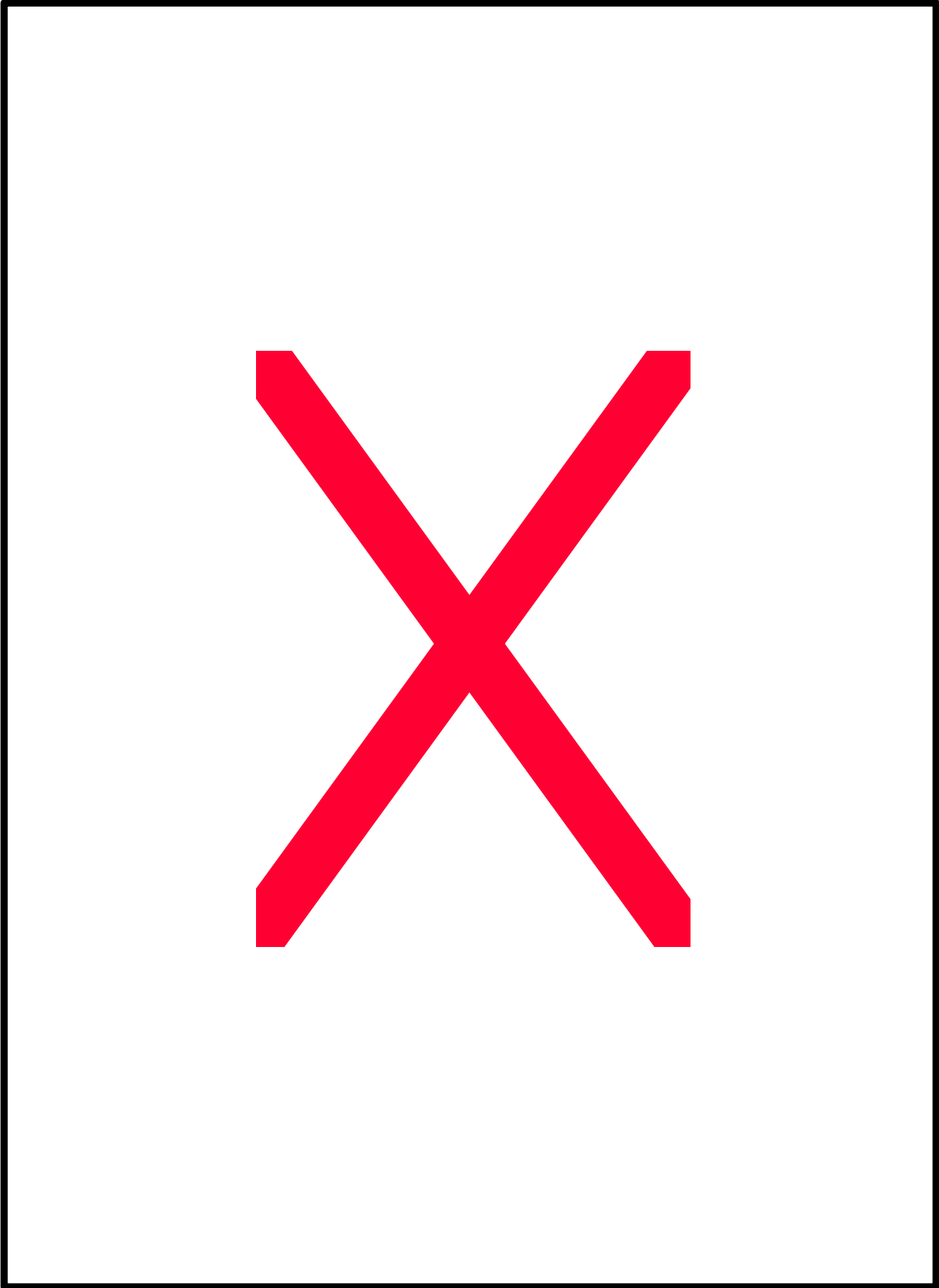
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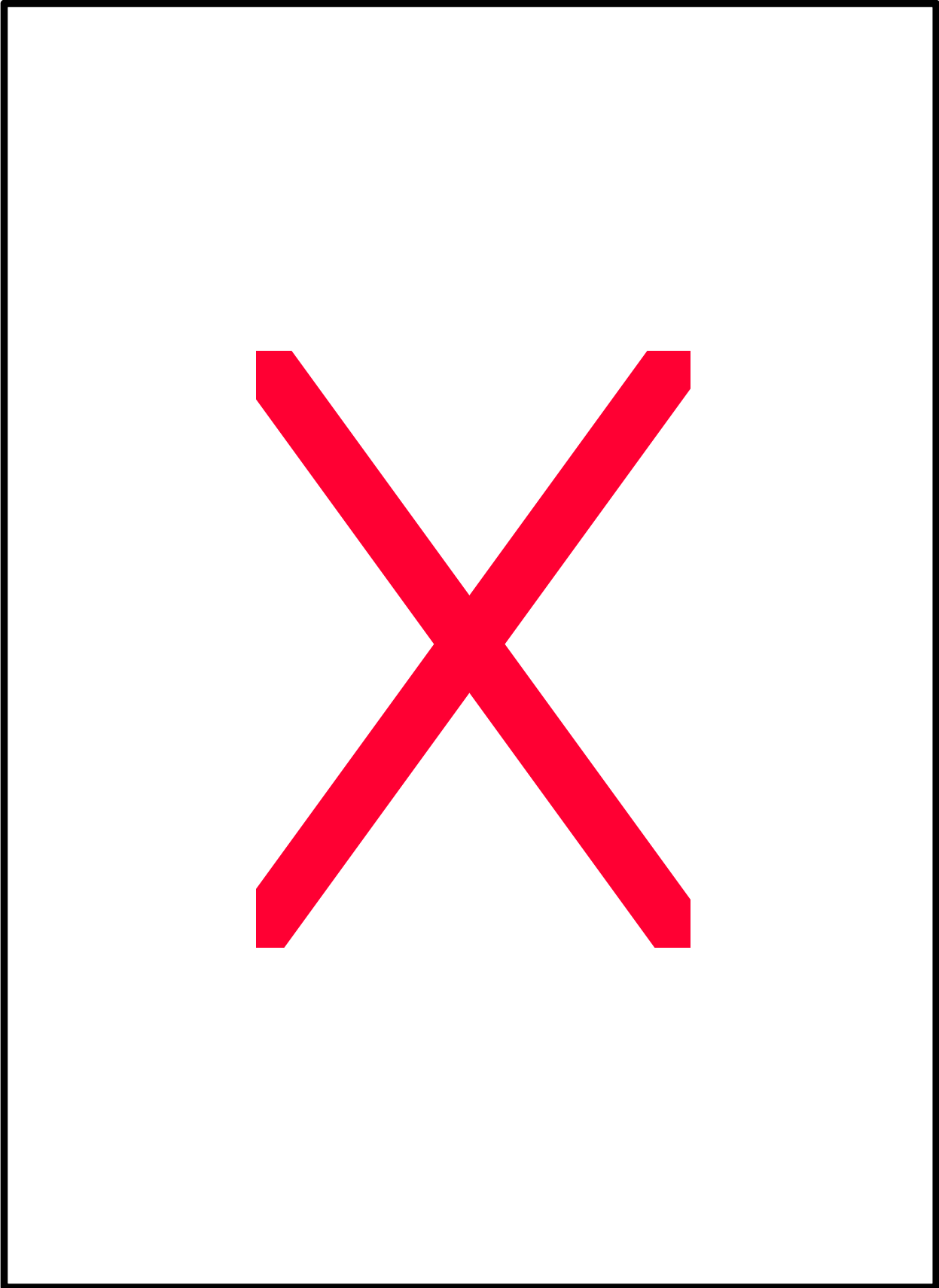
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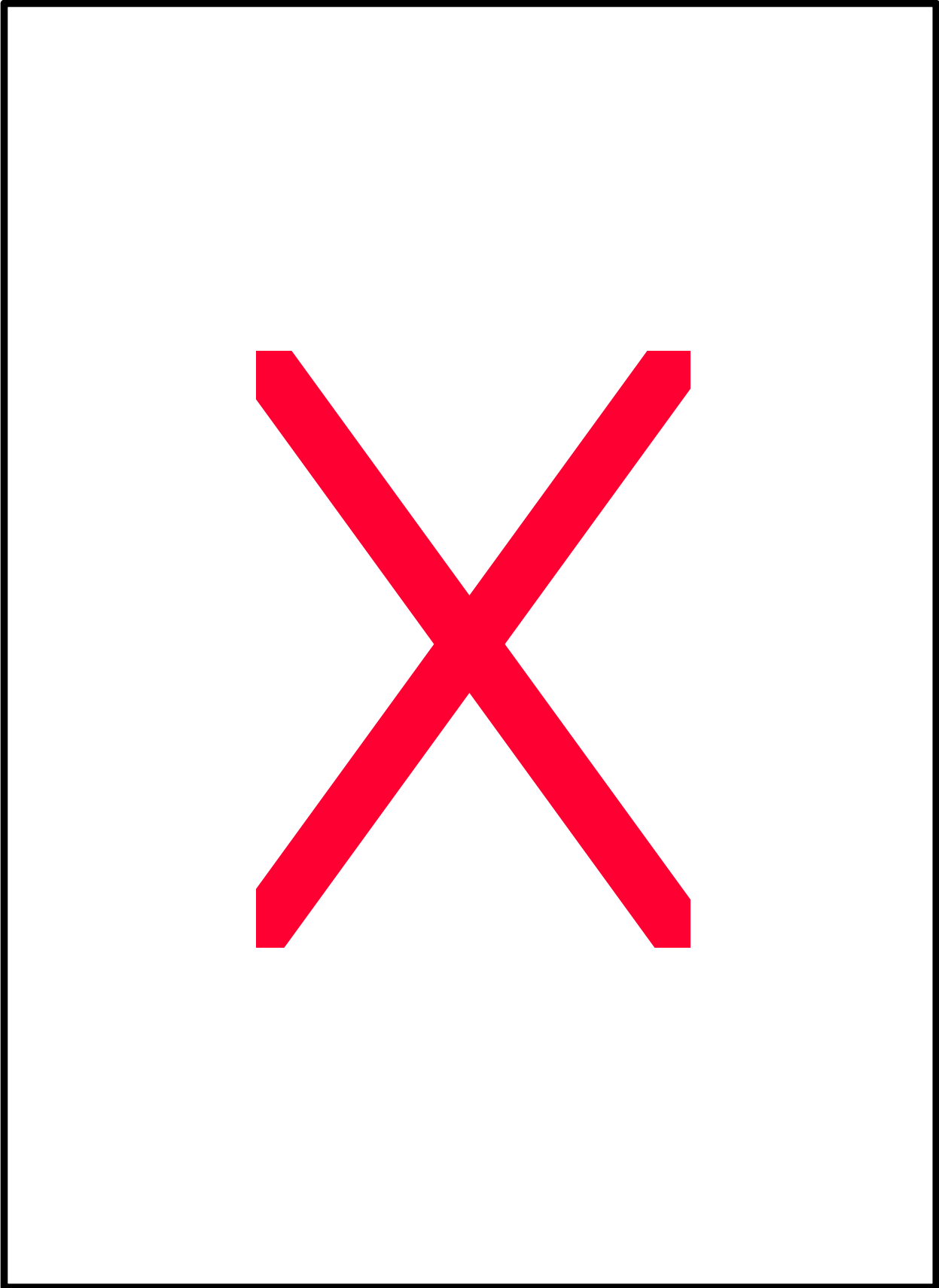


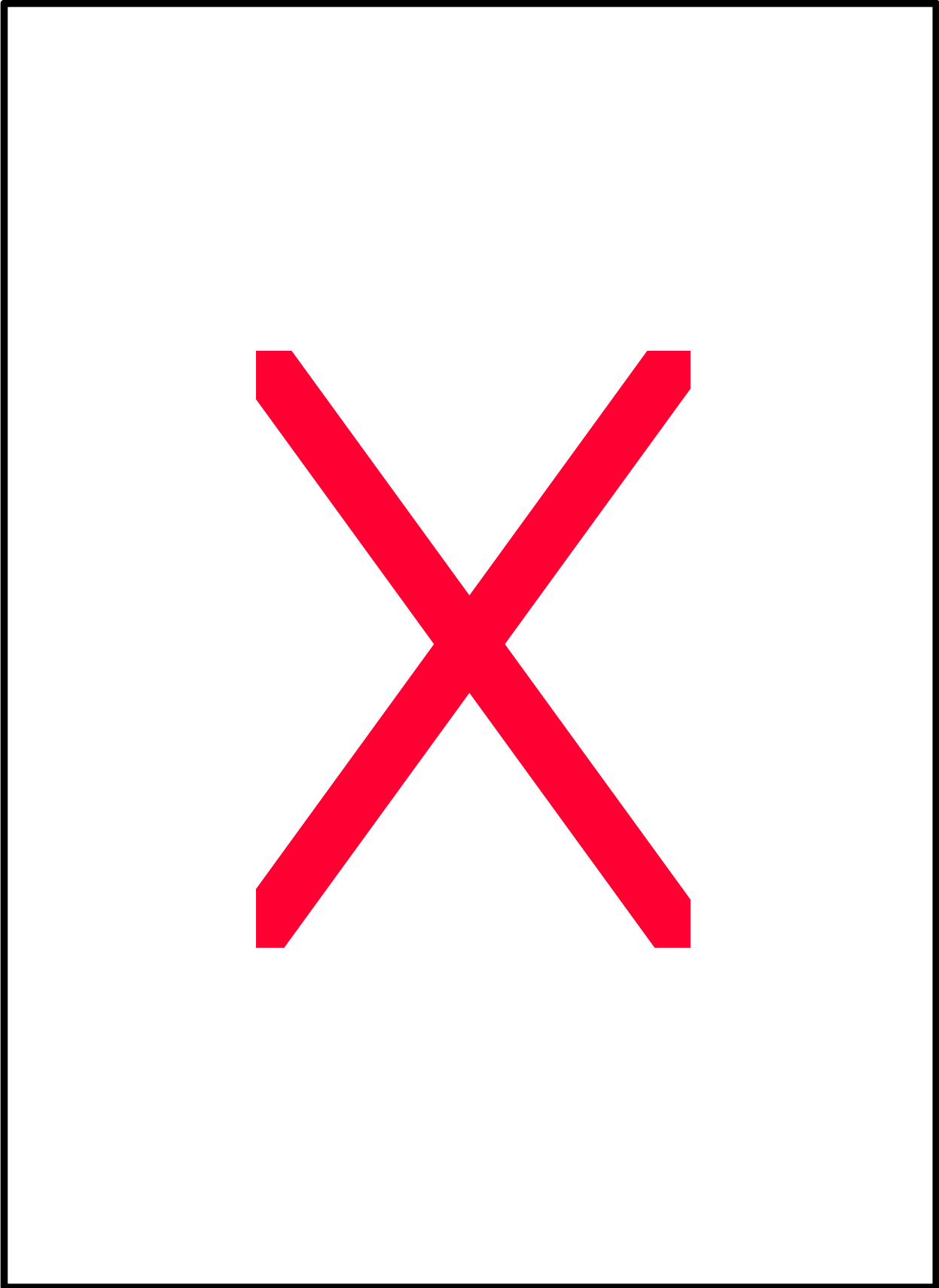




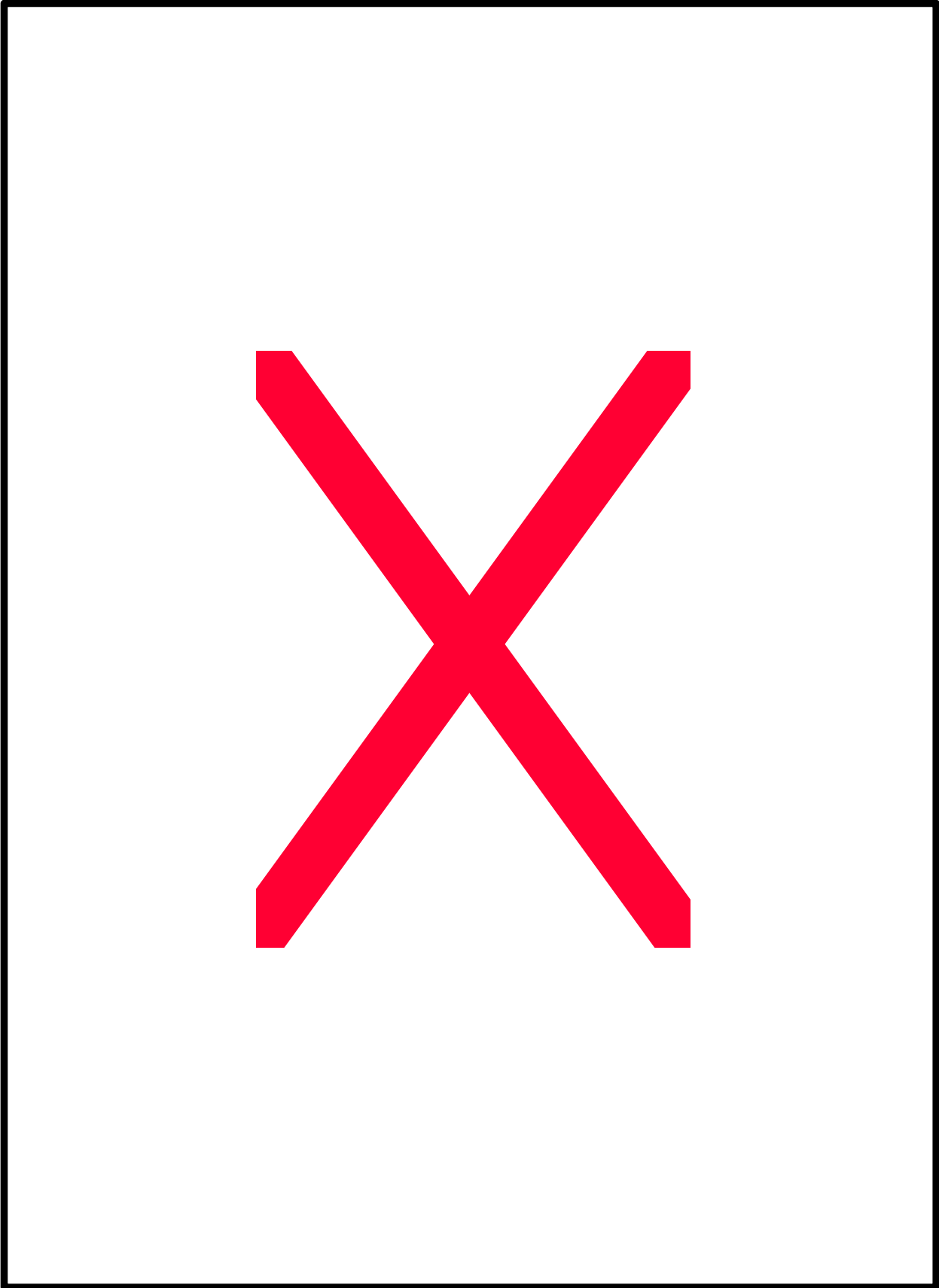
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